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THE PROBLEM OF AGE, GROWTH AND DEATH

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II. Cytomorphosis. The Cellular Changes of Age

Ladies and Gentlemen: I endeavored in my last lecture to picture to you, so far as words could suffice to make a picture, something of the anatomical condition of old age in man, and to indicate to you further that the study merely of those anatomical conditions is not enough to enable us to understand the problem we are tackling, but that we must in addition extend the scope of our inquiry so that it will include animals and plants, for since in all of these living beings the change from youth to old age goes on, it follows that we can hardly expect an adequate scientific solution of the problem of old age unless we base it on broad foundations. By such breadth we shall make our conclusion secure, and we shall know that our explanation is not of the character of those explanations which I indicated to you in the last lecture, which are so-called 'medical,' and are applicable only to man, but rather will have in our minds the character of a safe, sound and trustworthy biological conclusion. The problem of age is indeed a biological problem in its broadest sense, and we can not study, as we now know, the problem of age without including in it also the consideration of the problems of growth and the problems of death. I hope to so entice you along in the consideration of the facts, which I have to present, as to lead you gently but perceptibly to the conclusion that we can with the microscope now recognize in the living parts of the body some of those characteristics which result in old age. Old age has for its foundation a condition which we can actually make visible to the human eye. As a step towards this conclusion, I desire to show you this evening something in regard to the microscopic structure of the human body.

We now know that the bodies of all animals and plants are constituted of minute units so small that they can not be distinguished by the naked eye, although they can be readily demonstrated by the microscope. These units have long been known to naturalists by the name of cells. The discovery of the cellular constitution of living

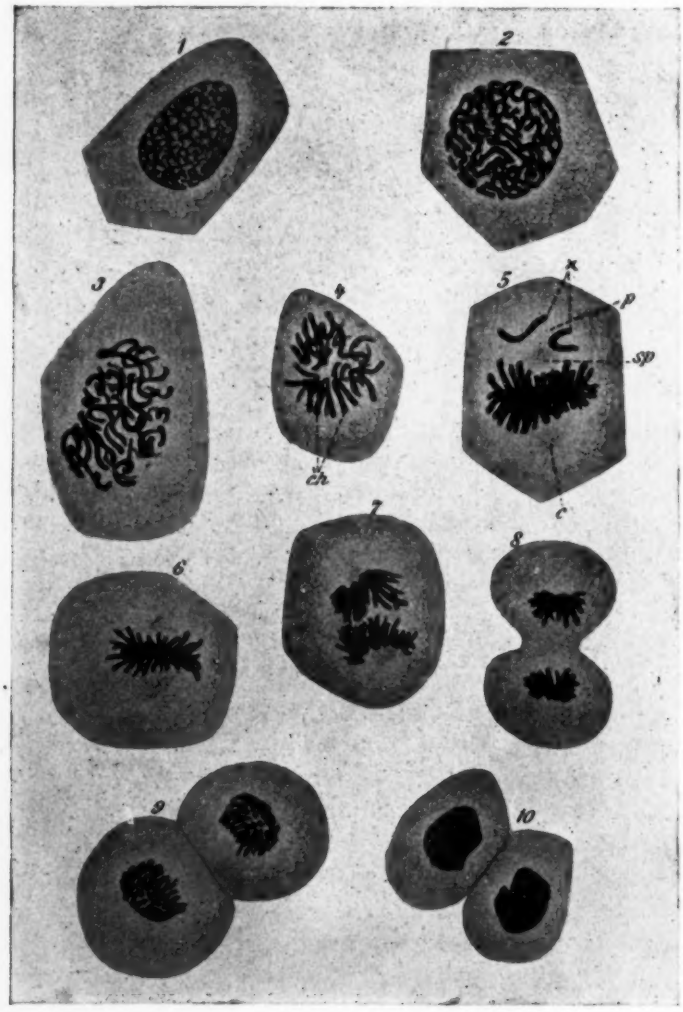


FIG. 3. CELLS FROM THE MOUTH (ORAL EPITHELIUM) OF THE SALAMANDER, to show the phases of cell division or mitosis.

bodies marks one of the great epochs in science, and every teacher who has had occasion to deal in his lectures with the history of the biological sciences finds it necessary to dwell upon this great discovery. It was first shown to be true of plants, and shortly after likewise of animals. The date of the latter discovery was 1839. We owe it to

Theodor Schwann, whose name will therefore ever be honored by all investigators of vital phenomena. What the atom is to the chemist, the cell is to the naturalist. Every cell consists of two essential parts. There is an inner central kernel which is known by the technical name of nucleus, and a covering mass of living material which is termed the protoplasm and constitutes the body of the cell. I will now call for the first of our lantern slides to be thrown upon the screen. It presents to you pictures of the cells as they are found lining the mouth of the European salamander. The two figures at the top illustrate very clearly the elements of the cell. The protoplasm forms a mass, offering in this view no very distinctive characteristics, and therefore offering a somewhat marked contrast with the nucleus which presents in its interior a number of granules and threads. Every nucleus consists of a membrane by which it is separated from the protoplasm, and three internal constituents: First, a network of living material, more or less intermingled with which is a second special substance, chromatin, which owes its name to the very marked affinity which it displays for the various artificial coloring matters which are employed in microscopical research. The third of the internal nuclear constituents we may call the sap, the fluid material which fills out the meshes of the network. Later on we shall have occasion to study somewhat more carefully the principal variations which nuclei of different kinds may present to us, and we shall learn from such study that we may derive some further insight into the rapidity of development and the nature of the changes which result in old age. While the picture is upon the screen, I wish to call your attention to the other figures which illustrate the process of cell multiplication. As you regard them you will notice in the succession of illustrations that the nucleus has greatly changed its appearance. The substance of the nucleus has gathered into separate granules, each of which is termed a chromosome. These chromosomes are very conspicuous under the microscope, because they absorb artificial stains of many sorts with great avidity and stand out therefore conspicuously colored in our microscopic preparations. They are much more conspicuous than is the substance of the resting nucleus. And this fact, that we can readily distinguish the dividing from the resting nucleus under the microscope, we shall take advantage of later on, for it offers us a means of investigating the rate of growth in various parts of the body. I should like, therefore, to emphasize the fact at the present time sufficiently to be sure that it will remain in your minds until the later lecture in which we shall make practical use of our acquaintance with it. It is unnecessary for our purposes to enter into a detailed description of the complicated processes of cell division. But let me point out to you that the end result is that where we have one cell we get as the result of division—two; but the

two divided cells are smaller than the mother cell and have smaller nuclei. They will, however, presently grow up and attain the size of their parent.

Every cell is a unit both anatomically and physiologically. It has a certain individuality of its own. In many cases cells are found to be isolated or separated completely from one another. But, on the other hand, we also find numerous instances in which the living substance of one cell is directly continuous with that of another. When the cells are thus related, we speak of the union of cells as syncytium. Of this I offer you an illustration in the second picture upon the screen, which represents the embryonic connective tissue of man. In this you can see the prolongations of the protoplasm of a single cell body uniting with the similar prolongations from other cell bodies, the cells themselves thus forming, as it were, a continuous network with broad meshes between the connecting threads of protoplasm. The spaces or meshes are, however, not entirely vacant, but contain fine lines which correspond to the existence of fibrils, which are characteristic of connective tissue and at the stage of development represented in this picture, are beginning to appear. It is fibrils of this sort which we find as the main elements in the constitution of sinews and tendons, as, for instance, the tendon of Achilles, at the heel. In a very young body we find there are but few fibrils; in the adult body an immense number.

There is, in fact, as you probably all know, a constant growth of cells; and this growth implies also, naturally, their multiplication. There has been in each of us an immense number of successive cell

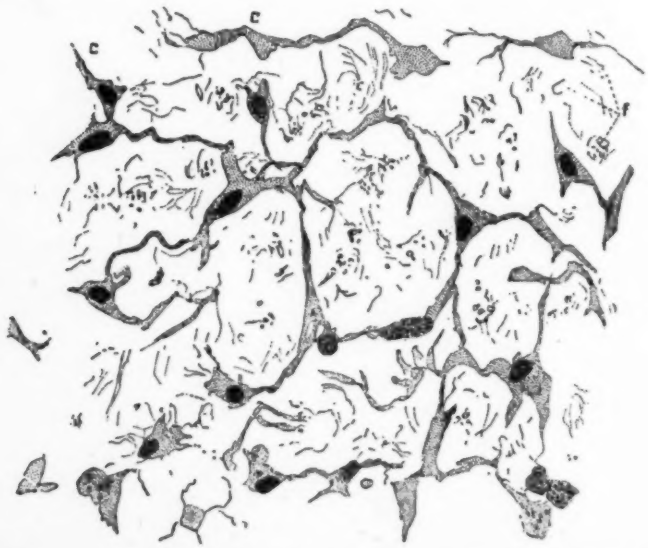


FIG. 4. EXAMPLE OF A SYNCYTIUM. Embryonic connective tissue from the umbilical cord of a human embryo of about three months, magnified about 400 diameters, *c*, *c*, cells; *f*, intercellular fibrils.

generations, and at the present time a multiplication of cells is going on in every one of us. It never entirely ceases as long as life continues. The development of the body, however, does not consist only of the growth and multiplication of cells, but also involves changes in the very nature of the cells, alterations in their structure. Cells in us are of many different sorts, but in early stages of development they are of few sorts. Moreover, in the early stages we find the cells all more or less alike. They do not differ from one another. Hence comes the technical term of differentiation, to designate the modifications which cells undergo with advancing age. At first cells are alike; in older individuals the cells have become of different sorts, they have been differentiated into various classes. This whole phenomenon of cell

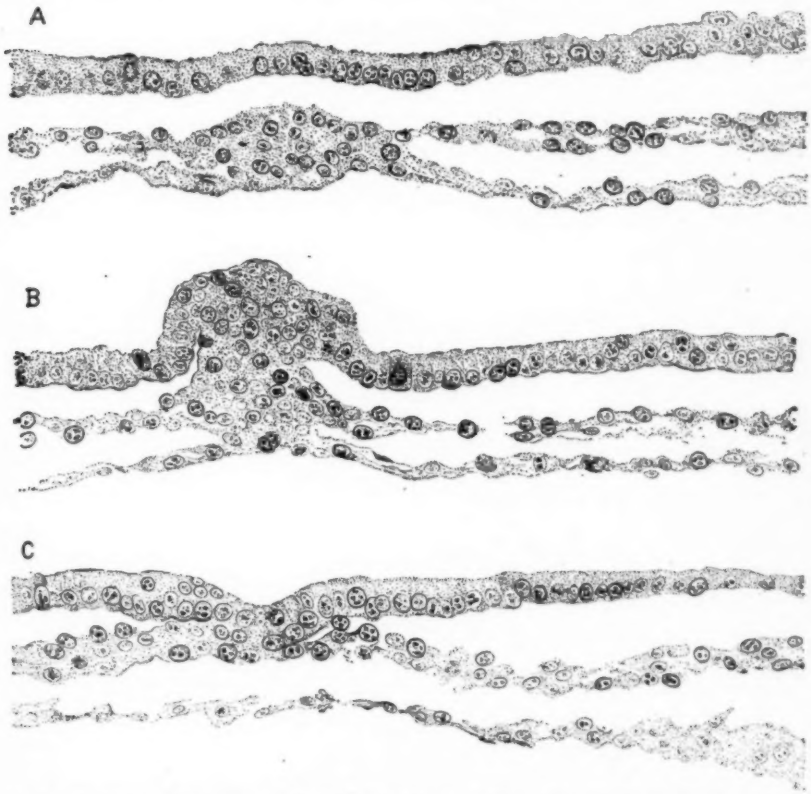


FIG. 5. THREE TRANSVERSE SECTIONS THROUGH A RABBIT EMBRYO OF SEVEN AND ONE HALF DAYS, from series 622 of the Harvard Embryological Collection. *A*, section 247 across the anterior part of the germinal area. *B*, section 260 across the middle region of the germinal area. *C*, section 381, through the posterior part of the germinal area. Magnified 300 diameters.

change is comprehensively designated by the single word, cytomorphosis, which is derived from two Greek words meaning *cell* and *form*, respectively. A correct understanding of the conception *cytomorphosis* is an indispensable preliminary to any comprehension of the phenomena of

development of animal or plant structure. I shall endeavor, therefore, now to give you some insight into the phenomena of cytomorphosis as regarded by the scientific biologist. The first cells which are produced are those which form the young embryo. We speak of them, therefore, as embryonic cells, or cells of the embryonic type. Our next picture illustrates the actual character of such cells as seen with the microscope, for it represents a series of sections through the body of a rabbit embryo, the development of which has lasted only seven and one half days. You will notice at once the simplicity of the structure. There are not yet present any of those parts which we can properly designate as organs. The cells have been produced by their own multiplication and are not yet so numerous but that they could be readily actually counted. They are spread out in somewhat definite layers or sheets. but beyond that they show no definite arrangement which is likely to attract your attention. That which I wish you particularly to observe is that in every part of each of these sections the cells appear very much alike. The nuclei are all similar in character, and for each of them there is more or less protoplasm; but the protoplasm in all parts of these young rabbits is found to be very similar; and indeed if we should pick out one of these cells and place it by itself under the microscope, it would be impossible to tell what part of the rabbit embryo it had been taken from, so much do all the cells of all the parts resemble one another. We learn from this picture that the embryonic cells are all very much alike, simple in character, have relatively large nuclei, and only a moderate amount of protoplasm for each nucleus to complete the cell.

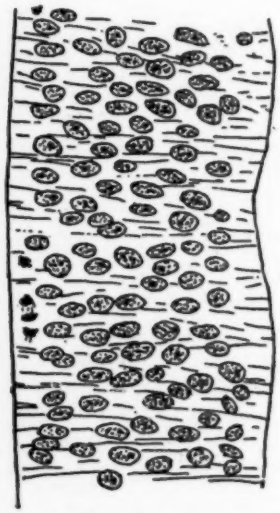


FIG. 6. PORTION OF A TRANSVERSE SECTION OF THE SPINAL CORD OF A HUMAN EMBRYO OF FOUR MILLIMETERS. Harvard Embryological Collection, series 714. The spinal cord at this stage is a tubular structure. The figure shows a portion of the wall of the tube; the lefthand boundary of the figure corresponds to the inner surface of the tube.

Very different is the condition of affairs which we find when we turn to the microscopic examination of the adult. Did time permit it would be possible to study a succession of stages and show you that the condition which we are about to study as existing actually in the adult is the result of a gradual progress and that in successive stages of the individual we can find successive stages of cell change; but it will suffice for our immediate purpose to consider the results of differentiation as they are shown to us by the study of the cells of

the adult. I will have thrown upon the screen for you a succession of pictures illustrating various adult structures. The first is, however, a section of the embryonic spinal cord in which you can see that much of the simple character of the embryonic cells is still kept. All parts of the spinal cord, as the picture shows, are very much alike, and the nuclei of the cells composing the spinal cord at this stage are all essentially similar in appearance. What a contrast this forms with our next picture, which shows us an isolated so-called motor nerve cell from the adult spinal cord. It owes its name motor to the fact that it produces a nerve fiber by which motor impulses are conveyed from the spinal cord to the muscles of the body. The cell has numerous elongated branching processes stretching out in various directions, but all leading back towards the central body in which the nucleus is situated. These are the processes which serve to carry in the nervous impulses from the periphery towards the center of the cell, impulses which in large part, if not exclusively, are gathered up from other nerve cells which act on the motor element. At one point there runs out a single process of a different character. It is the true nerve fiber, and forms the axis, as it was formerly termed; or axon, as it is at present more usually named, of the nerve fiber as we encounter it in an ordinary nerve. This single thread-like prolongation of the nerve cell is likewise constituted by the living protoplasm and serves to carry the impulses away from the cell body and transmit them ultimately to the muscle fibers which are to be stimulated to contraction. In the embryonic

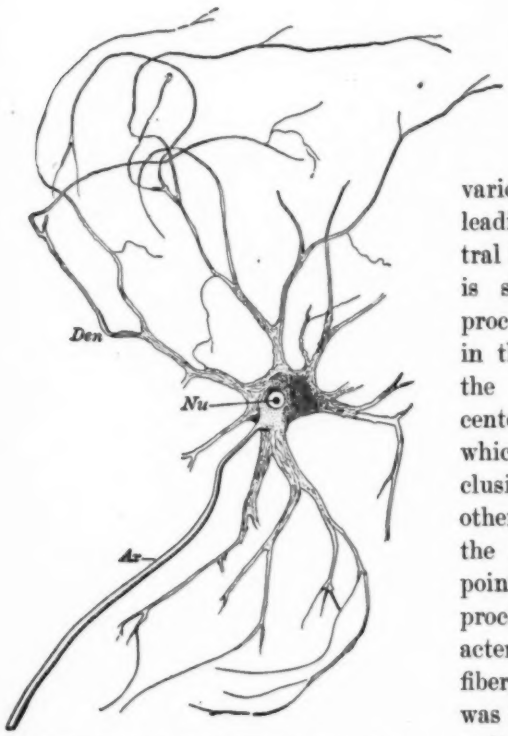


FIG. 7. COPY OF THE ORIGINAL FIGURE FROM THE MEMOIR OF DEITERS, in which the proof of the origin of the nerve fibers directly from the nerve cells was first published. The memoir is one of the classics of anatomy. It was issued posthumously, for the author died young to the great loss of science. The figure represents a single isolated motor nerve cell from the spinal cord of an ox. The single unbranched axon Ax, is readily distinguished from the multiple branching dendrites.

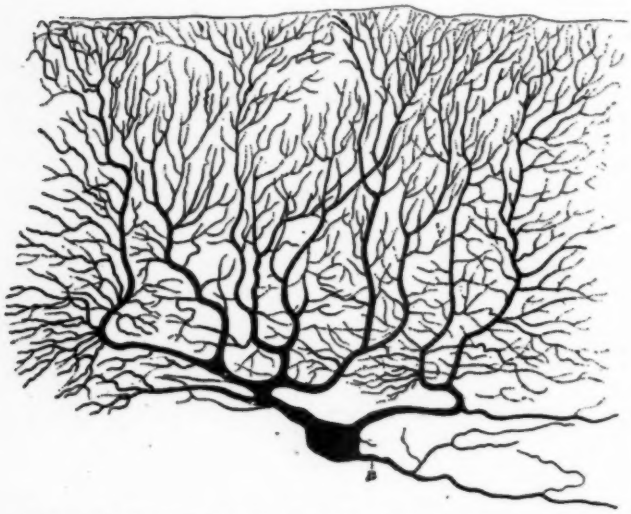


FIG. 8 A LARGE CELL FROM THE SMALL BRAIN (CEREBELLUM) OF A MAN. It is usually called a Purkinje's cell. It was stained black throughout by what is known as the Golgi silver method, hence shows nothing of its internal structure. After von Kölliker.

spinal cord none of these processes existed, and the amount of the protoplasm in the nerve cell was very much smaller. As development progressed, not only did the protoplasm body grow, but the processes gradually grew out. Some of them branched so as to better receive and collect the impulses; one of them remained single and very much elongated, and acquired a somewhat different structure in order to serve to carry the nervous impulses away. The third picture[1] shows us a section through the spinal cord of an adult fish. It has been treated by a special stain in order to show how certain elements of the spinal cord acquire a modification of their organization by which they are adapted to serve as supports for the nervous elements proper. They play in the microscopic structure the same supporting rôle which the skeleton performs in the gross anatomy of the body as a whole. They do not take an active part in the nervous functions proper. None of the appearances which this figure offers for our consideration can be recognized in any similar preparation of the embryonic cord. Obviously, then, from the embryonic to the adult state in the spinal cord there occurs a great differentiation. That which was alike in all its parts has been so changed that we can readily see that it consists of many different parts. A striking illustration of this is afforded by the next picture, which represents one of the large nerve cells which occur in the small brain, or cerebellum, that portion of the central nervous system which the physiologists have demon-

[1] The illustration referred to is not reproduced in the text.

strated to be particularly concerned in the regulation and coordination of movements. These large cells occur only in this portion of the

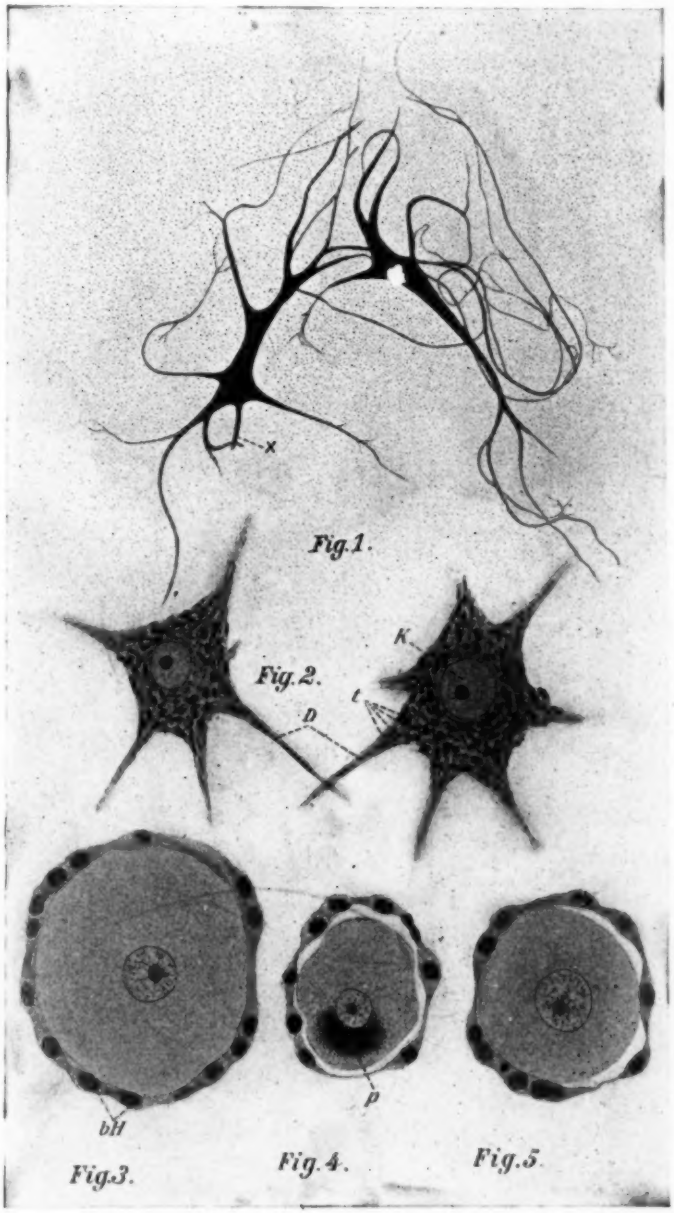


FIG. 9 VARIOUS KINDS OF HUMAN NERVE CELLS, AS DESCRIBED IN THE TEXT. After Sobotta.

brain, and, as you see, differ greatly in appearance from the motor cells of the type which we were considering a few moments ago. And, again,

another picture illustrates yet other peculiarities of the adult nerve cells. The upper figures in this plate are taken from cells which have been colored uniformly of a very dark hue, in consequence of which

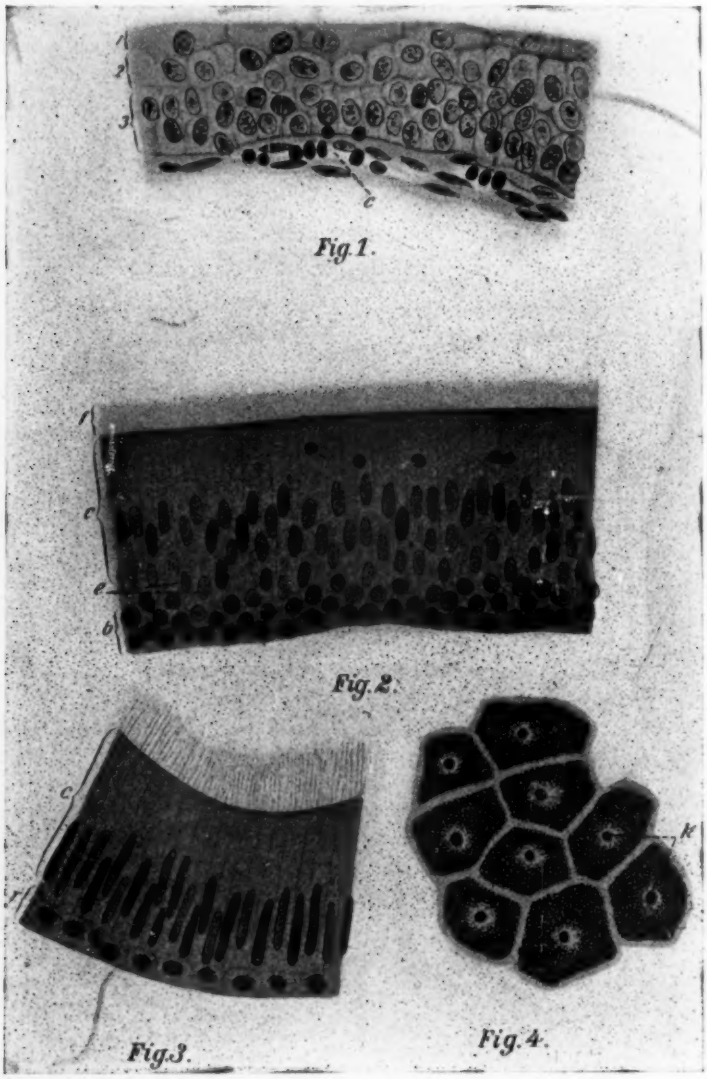
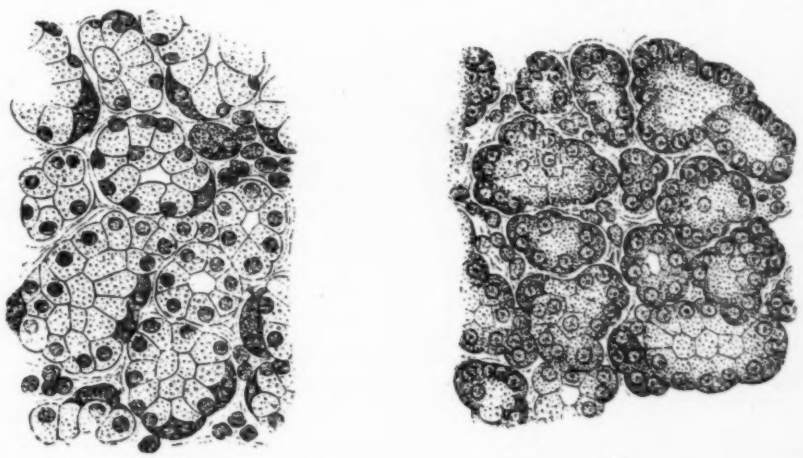


FIG. 10. SECTIONS OF FOUR SORTS OF EPITHELIUM. After Sobotta.

they are rendered so opaque that the nucleus which they really contain is hidden from our view. But the deep artificial color makes it easy to follow out the form of the cells and the ramifications of their long processes. In the middle figures we have cells which have been stained by another method which brings out very clearly to the eye the fact

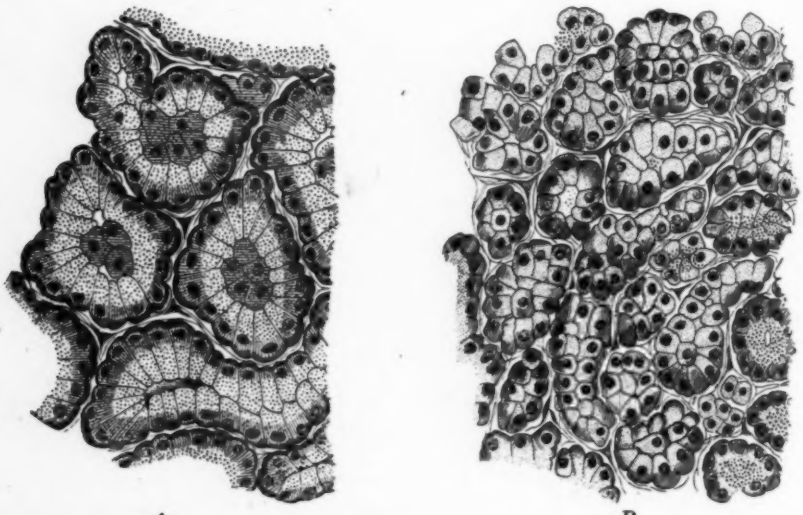
that in the protoplasm of the cell there are scattered spots of substance of a special sort. No such spots can be demonstrated in the elements of the young embryonic nerve cells. To some fanciful observers the spots, thus microscopically demonstrable in the nerve cells, recall the spots which appear on the skin of leopards, and hence they have bestowed upon these minute particles the term tigroid substance. The bottom figures represent the kind of nerve cells which occur upon the roots of the spinal nerves. It is unnecessary to dwell upon their appearance, as the mere inspection of the figures shows at once that they differ very much indeed from the other nerve cells we have considered. We pass now to another group of structures, the tissues which are known by the technical name of epithelia. You can notice immediately in the figures from the skin that the appearances are very different from those we have encountered in contemplating the cells of the nervous system. And you can readily satisfy yourselves by the comparison with the various figures now before you, of the fact that these epithelia are unlike one another. The figures represent epithelium, respectively, first from the human ureter; second, from the respiratory division of the human nose; third, from the human ductus epididymidis, and fourth, from the pigment layer of the retina of the cat. We turn now to a representation of a section of one of the orbital glands. This is very instructive because we see not only that the cells which compose the gland have acquired a special character of their own, but also that they are not uniform in their appearances. This lack of uniformity is due chiefly to the fact that the cells change their appearance according to their functional state. We can actually see in these cells under the microscope the material imbedded in their protoplasmic



A *B*

FIG. 11. TO SHOW THE ORBITAL GLANDS, *A*, with the material to form the secretion accumulated within the cells. *B*, after loss of the material through prolonged secretion. From R. Heidenhain after Lavdowsky.

bodies out of which the secretion, which is to be poured forth by the cells, is to be manufactured. So long as that material for the secretion is contained in the cells, the cells appear large, and their protoplasmic bodies do not readily absorb certain of the staining matters, which the microscopist is likely to apply to them. When, however, the accumulated raw material has been changed into the secretion and discharged from the gland, the cell is correspondingly reduced in bulk, and as you see in this figure, it then takes up the stain with considerable avidity, as does also the nucleus which has likewise become reduced in size. These facts are very instructive for us, since they prove conclusively that with the microscope we can see at least part of the peculiarities in cells which are correlated with their functions. We can actually observe that the cells of the salivary glands are able to produce their peculiar secretion because they contain a kind of substance which in the embryonic cell does not appear at all. There is a visible differentiation of these salivary cells from the simple stage of the embryonic cells. Something similar to this can be recognized in the next of our pictures representing a section of the gland properly known as the pancreas, but which is sometimes termed the abdominal salivary gland for the reason that it somewhat resembles the true salivary. In the cells of the pancreas also we can see the material, which is to produce the secretion, accumulated in the inner portion of the cell, and when it is so accumulated the cell appears enlarged in size and the nucleus is driven back towards the outer end of the cell where some unaltered protoplasm is also accumulated. When this raw material is turned



A *B*

FIG. 12. TWO SECTIONS OF THE PANCREATIC GLAND OF A DOG. *A*, the cells are enlarged by the accumulation of material to form the secretion. *B*, the cells are shrunk because there has been prolonged secretion and part of their substance is lost. From R. Heidenhain.

over into secretion by a chemical change, it is discharged from the cell, the cell loses in volume and in its shrunken state presents a very different appearance, as is shown at *B* in the figure. It is necessary for the cells to again elaborate the material for secretion before they can a second time become functionally active. Here we have something of the secret of the production of the various juices in the body revealed to us. Other excellent examples of the differentiated condition of the cells are afforded us by the examination of hairs, of which I will show you two pictures. The first represents a section through the human

FIG. 13. SECTION OF THE HUMAN SKIN, MADE SO THAT THE HAIRS ARE CUT LENGTHWISE.

skin taken in such a way that the hairs are themselves cut lengthwise and you can see not only that each hair consists of various parts, but also that the cells in these parts are unlike. The follicles within the skin in which the hair is lodged likewise have walls with cells of various sorts. It may interest you also to point out in the figure the little muscle which runs from each hair to the overlying skin, so disposed that when the muscle contracts the "particular hair will stand up on

end." Still more clearly does the variety of cells which actually exists in a hair show in the following picture, which represents a cross-section of a hair, and its follicle, but more highly magnified than were the hairs in the previous figure. The adult body consists of numerous organs. These are joined together and kept in place by intervening

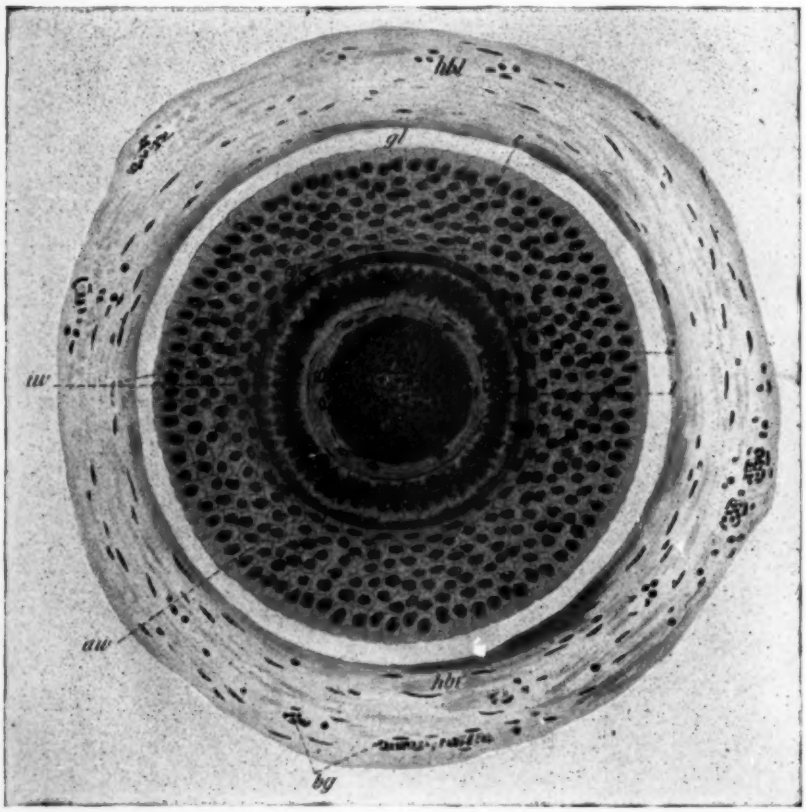


FIG. 14. CROSS SECTION OF THE ROOT OF A HAIR.

substance. The organs themselves consist of many separate parts which are also joined by a substance which keeps them in place. This substance has received the appropriate name of connective tissue. We find in the adult that it consists of a considerable number of structures. There are cells and fibers of more than one kind, which have been produced by the cells themselves. There is more or less substance secreted by the cell which helps to give consistency to the tissue. In some cases this substance which is secreted by the cells becomes tougher and acquires a new chemical character. Such is the case, for instance, with cartilage. Or, again, you may see a still greater chemical metamorphosis going on in the material secreted by the cells in the case of bone, where the substance is made tougher and stronger by the deposit

of calcareous material. Nothing like cartilage, nothing like bone, exists in the early state of the embryo. They represent something different and new. The next of our illustrations shows us a muscle fiber of the sort which serves for our voluntary motions, which is connected typically with some part of the skeleton. These muscle fibers are elongated structures. Each fiber contains a contractile substance different from protoplasm, and which exists in the form of delicate fibrils which run lengthwise in the muscle fibers, and is so disposed, further, that a series of fine lines are produced across the fiber itself, each line corresponding with a special sort of material different from the original protoplasm. These cross lines give to the voluntary muscle fibers a very characteristic appearance, in consequence of which they are commonly designated in scientific treatises by the term striated. A striated muscle fiber is that which is under the control of our will. It should perhaps be mentioned that the muscle fibers of the heart are also striated, though they differ very much in other respects from the true voluntary muscles. And last of all for this series of demonstrations, I have chosen a representation of the retina. One can see at the top of the figure the peculiar cylindrical and developing projections, which are characteristic of a retina, projections which are of especial interest because they represent the apparatus by which the rays of light are transformed into an actual sensory perception.

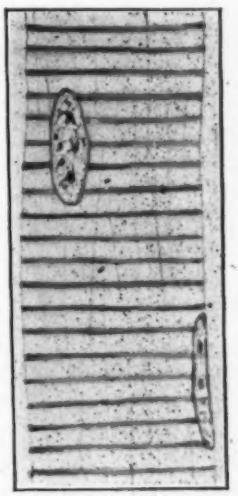


FIG. 15. PART OF A MUSCLE FIBER OF THE HUMAN TONGUE TO SHOW THE CROSS STRIATIONS. Two nuclei are included, one of which is shown at the edge of the fiber, the other in surface view. In the adult striated muscle fibers of mammals the nuclei are superficially placed.

After this has been accomplished, the perception is transmitted into the interior substance of the retina, and by the complication of the figure you may judge a little of the complication of the arrangements by which the transmission through this sensory organ is achieved, until the perception is given off to a nerve fiber and carried to the brain. There is not time to analyze all I might present to you of our present knowledge concerning the structure of the retina. But it will, I think, suffice for purposes of illustration to call your attention to the complicated appearance of the section as a whole and to assure you that nothing of the sort exists in the early stage of the embryo. To recapitulate, then, what we have learned from the consideration of these pictures, we may say that in place of uniformity we now have diversity. It should be added, to make the story complete, that the establishment of this diversity has been gradually brought about, and that that which

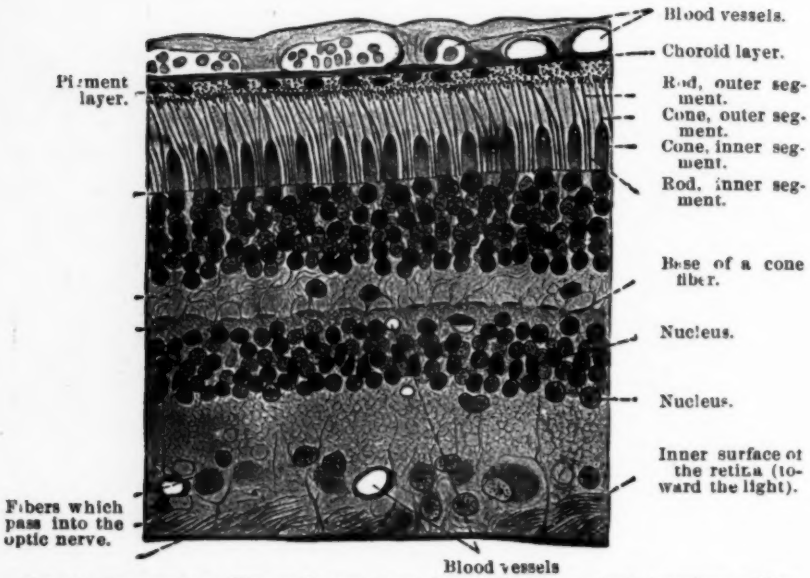


FIG. 16. SECTION OF A HUMAN RETINA, from Stöhr's Histology, sixth American edition. Although the retina is very thin it comprises no less than twelve distinct layers; the outermost layer is highly vascular. The pigment layer prevents the escape of light. The rods and cones convert the light waves into a sensory impulse, which is transmitted through the remaining layers of the retina to the optic nerve. The total structure is extremely complicated.

we call development is in reality nothing more than the making of diversity out of uniformity. It is a process of differentiation. Differentiation is indeed the fundamental phenomenon of life; it is the central problem of all biological research, and if we understood fully the nature of differentiation and the cause of it, we should have probably got far along towards the solution of the final problem of the nature of life itself.

The size of animals deserves a few moments of our time, for it is intimately connected with our problem of growth and differentiation. Cells do not differ greatly from one another in size. The range of their dimensions is very limited. This is particularly true of the cells of any given individual animal. Recent careful investigations have been made upon the relation of the size of cells to the size of animals, and it has been found that animals are not larger, one than another, because their cells are larger, but because they have more of them. This statement must be understood with certain necessary reservations. There are some kinds of animals, like the star-fish, which have very small cells; others, like frogs and toads, which have large cells; so that a star-fish of the same bulk as a given frog would contain a great many more cells. Our statement is true of allied animals. For example, a large frog differs from a small frog, or a large dog from a small dog by the number of the cells. An important exception to this law is offered for our consideration by the cells of the central nervous

system, the nerve cells properly so called. This is demonstrated by the slide now before us, which shows us corresponding motor nerve cells of twelve different animals arranged in the order of their size—the elephant, the cow, the horse, man, the pig, the dog, the baboon, the cat, the rabbit, the rat, the mouse, and a small bat. You recognize im-

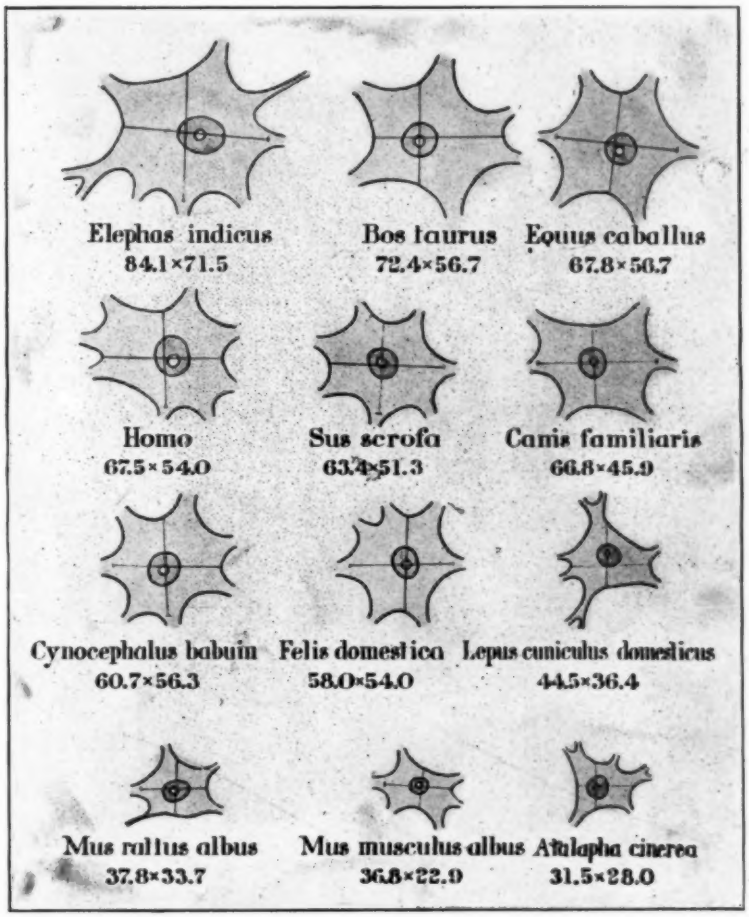


FIG. 17. MOTOR NERVE CELLS OF VARIOUS MAMMALS, all from the cervical region of the spinal cord. The cells are represented, all uniformly magnified. After Irving Hardesty.

mediately that there is a proportion between the size of these cells and the size of the respective species of animals. To a minor degree, but much less markedly, there is a difference in the caliber and length of the muscle fibers. But with these exceptions our statement is very nearly exactly true, that the difference in size of animals does not involve a difference in the size of their cells. For the purpose of the study of development, which we are to make in these lectures, this uni-

formity in the size of cells is a great advantage, and enables us to speak in general terms in regard to the growth of cells, and renders it superfluous to stop and discuss for each part of the body the size of the cells which compose it, or to seek to establish different principles for different animals because their cells are not alike in size.

Now we pass to a totally different aspect of cell development, that which is concerned with the degeneration of cells. For we find that,

FIG. 18. CHANGES IN THE NERVE CELLS WITH AGE.

after the differentiation has been accomplished, there is a tendency to carry the change yet further and to make it so great that it goes beyond perfection of structure, so far that the deterioration of the cell comes as a consequence. Such cases of differentiation we speak of as a degeneration, and it may occur in a very great number of ways. Very frequently it comes about that the alteration in the structure of the cell goes so far in adapting it to a special function that it is unable to maintain itself in good physiological condition, and failing to keep up its own nourishment it undergoes a gradual shrinkage which we call atrophy. A very good illustration of this, and a most important one, is offered us by the changes which go on in the nerve cells in extreme old age. This is beautifully illustrated by the two pictures which are now before us, copied from investigations of Professor Hodge, of Clark University. The two figures represent human nerve cells taken from the root of a spinal nerve. The left-hand figure shows these cells as they exist in their full maturity; the right-hand figure, as they appear in a person of extreme old age. In the latter you will readily notice that the cells have shrunk and no longer fill

the spaces allotted to them, the nuclei have become small, and the protoplasm has changed its appearance very strikingly because there have been deposited in it granules of the pigment which impart to these cells an appearance very different from that which they had in their maturity when their functional powers were at their maximum. You will notice also in other parts of the right-hand figure that the atrophy of the cells has led on to their disintegration, that they are breaking down, being destroyed, and that the result of their breaking down will ultimately be their disappearance. Thus the atrophy of a cell may lead to its death. The other two figures[1] upon the screen show us the brain of the humble bee. On the left is the brain of the bee in the condition in which we find it when the bee first emerges from the pupa or chrysalis. The cells are then in a fine physiological condition, but in a few weeks at most the bee becomes old and in the space which belongs to each cell we find only its shrunken and atrophied remnants, the nucleus greatly reduced in volume, and an irregular mass of protoplasm shrunk together around it. These cells have likewise undergone an atrophy and are on their way to death. In other cases we find that there is a change going on which we call necrobiosis, which means that the cells continue to live, but change their chemical organization so that their substance passes from a living to a dead state. No more perfect illustration of this sort of change can be found than that which is afforded by the skin. In the deep layer of the outer skin are the living and growing parts, which we all know from experience are sensitive. As these multiply some of them move up towards the surface; and they are continually shoved nearer and nearer the surface by the growth of the cells underneath. They finally become exposed at the surface by the loss of the superficial cells which preceded them. During this migration the protoplasm of each cell, which was alive, is changed chemically into a new substance which we call keratin, or in common language, horny substance. Ultimately the cell protoplasm becomes nothing but horny substance and is absolutely dead. Here life and death play together and go hand in hand. Hence the term necrobiosis, life and death in one. Another form of degeneration which occurs in many cases is of great interest because it seems as if the cells were making a last great effort; and their final performance is one of enlargement. They become greater in size than before; but there will follow a disintegration of these cells also; and they break down and are lost. This form of degeneration is termed hypertrophic, and represents a third type, as I have stated. In all parts of the body degenerative changes are going on, and they represent collectively a third phase in the cytomorphic cycle. But there is yet one more phase, which is needed to complete the story. That is the phase of the

[1] The two figures of the bee's brain are not reproduced in the text.

death and final removal of the cells. The degenerative change always results in the death of the cell. In many cases the dead material is removed merely by being cast off, as is the case with the skin. All the scales which peal off from the outer surface of our body represent little scraps or clusters of cells which are entirely dead; and in the interior of the body, in the intestinal canal, and in the glands of the stomach, we find cells continually dying, dropping off from their place upon the walls, and being cast away. Or if we examine the saliva which comes from the mouth, we detect that that also is full of cells which have died and fallen off from their connection with the body and are thus removed. An even more important method of the removal of cells is by a chemical process in consequence of which the cells are dissolved and disappear before our eyes, very much as marble may disappear from sight under the corrosive action of an acid. Indeed, we know that all the parts of the body, so far as they are alive, produce within themselves a ferment which has a tendency to destroy the living substance itself. The production of these destructive agents is going on at all times, apparently, in all parts of the body, which are alive. A striking illustration of this is offered in the stomach. The digestive juice which is produced in the stomach is capable of attacking and destroying living substance, and any organic material suitable for food which is placed in the stomach will, as we know, be attacked by the gastric juices, dissolved to a certain extent by them, and so destroyed. Why then does the gastric juice not attack the stomach itself? This is but one phase of the problem why the body does not continually destroy itself. It has lately been ascertained by some ingenious physiological investigations that the body not only produces the destructive agents, but also antagonists thereto, anti-compounds which tend to prevent the activity of the destroying factors. The whole problem is one of great interest and importance which calls for very much further investigation before we can be said to have arrived at a clear understanding of it. But it helps us much in our conception of cytomorphosis to know that all portions of the body are endowed with this faculty of destroying themselves, for it enables us to understand how it is possible that after the degeneration of a cell it will be dissolved away. It is merely that the agents of solution which are ordinarily held at bay are no longer restrained, and they at once do their work. There is another, but comparatively rare, mode of cell-destruction. The cells break up into separate fragments, which are then dissolved by chemical means and disappear, by the method of histolysis above described, or else are devoured by the cells, to which reference was made in the first lecture, and which are known by the name of phagocytes, and to which Metchnikoff has attributed so great an importance. It is unquestionable that phagocytes do eat up fragments of cells and of tissues,

and may even attack whole cells. But to me it seems probable that their rôle is entirely secondary. They do not cause the death of cells, but they feed presumably only upon cells which are already dead or at least dying. Their activity is to be regarded, so far as the problem of the death of cells is concerned, not as indicating the cause of death, but as a phenomenon for the display of which the death of the cell offers an opportunity. The subject of the death and disintegration of cells is an exceedingly complex one, and might well occupy our attention for a long time. But it is not permissible to depart from the strict theme which we have before us, and I will content myself, therefore, with throwing upon the screen two tables[2] which illustrate to us the variations in the death of cells and in their modes of removal which are

[2] I. Death of Cells

First. Causes of death.
- *A.* External to the organism:
  - (1) Physical (mechanical, chemical, thermal, etc.).
  - (2) Parasites.
- *B.* Changes in intercellular substances (probably primarily due to cells):
  - (1) Hypertrophy.
  - (2) Induration.
  - (3) Calcification.
  - (4) Amyloid degeneration (infiltration).
- *C.* Changes inherent in cells:

Second. Morphological changes of dying cells.
- *A.* Direct death of cells:
  - (1) Atrophy.
  - (2) Disintegration and resorption.
- *B.* Indirect death of cells:
  - (1) Necrobiosis (structural change precedes final death).
  - (2) Hypertrophic degeneration (growth and structural change often with nuclear proliferation precede final death).

Third. Removal of cells.
- *A.* By mechanical means (sloughing or shedding)
- *B.* By chemical means (solution).
- *C.* By phagocytes.

II. Indirect Death of Cells

A. Necrobiosis.
- (1) Cytoplasmic changes:
  - (*a*) Granulation.
  - (*b*) Hyaline transformation.
  - (*c*) Imbibition.
  - (*d*) Desiccation.
  - (*e*) Blasmatosis.
- (2) Nuclear changes:
  - (*a*) Karyorhexis.
  - (*b*) Karyolysis.

B. Hypertrophic degeneration.
- (1) Cytoplasmic:
  - (*a*) Granular.
  - (*b*) Cornifying.
  - (*c*) Hyaline.
- (2) Paraplasmic:
  - (*a*) Fatty.
  - (*b*) Pigmentary.
  - (*c*) Mucoid.
  - (*d*) Colloid, etc.
- (3) Nuclear (increase of chromatin).

known at the present time. These tables are taken from a lecture which I delivered in New York a few years ago, which was subsequently published. If any of you should care to make a closer acquaintance with them they are therefore readily accessible to you. How then, from the standpoint of cytomorphosis ought we to look upon old age? Cytomorphosis, the succession of cellular changes which goes on in the body, is always progressive. It begins with the earliest development, continues through youth, is still perpetually occurring at maturity and in old age. The rôle of the last stage of cytomorphosis, that is, of death in life, is very important, and its importance has only lately become clear to us. I doubt very much if the conception is at all familiar to the members of this audience. Nevertheless the constant death of cells is one of the essential factors of development, and much of the progress which our bodies have made during the years we have lived, has been conditional upon the death of cells. As we have seen, cytomorphosis, when it goes through to the end, involves not only the differentiation but the degeneration and death of the parts. There are many illustrations of this which I might cite to you as examples of the great importance of the destruction of parts. Thus there is in the embryo before any spinal column is formed an actual structure which is termed the notochord. In the young mammalian embryo this structure is clearly present and plays an important part, but in the adult it has entirely disappeared, and its disappearance begins very early during embryonic life. There are numerous blood vessels which we find to occur in the embryo, both those which carry the blood away from the heart and those which bring blood to the heart, which during the progress of development are entirely destroyed, and disappear forever. Knowledge of these is to the practical anatomist and surgeon often of great importance. Vast numbers of the smaller blood vessels which we know commonly by the name of capillaries, exist only for a time and are then destroyed. There is in the young frog, while he is in the tadpole stage, a kidney-like organ, which on account of its position is called the head-kidney, but it exists only during the young stage of the tadpole. There is later produced another kidney which, from its position, is called the middle kidney, and which is the only renal organ found in the adult, for the head kidney entirely disappears in these animals long before the adult condition is reached. In the mammal there is yet a third kindey. We have during the embryonic stage of the mammal always a well-developed excretory organ which corresponds to the middle or permanent kidney of the frog, yet during embryonic life the greater part of this temporary structure is entirely destroyed. It is dissolved away and vanishes, leaving only a few remnants of comparatively little importance in the adult. The new structure, the permanent kidney which we have, takes its place

functionally. Large portions of the tissues, which arise in the embryo, are destroyed at the time of birth, and take no share in the subsequent development of the child. If we follow out with the microscope the various changes which go on in the developing body we see revealed to us a very large number of cases of death of tissues, followed by their removal. Thus the cartilage which exists in the early stages dies and is dissolved away, and its place is taken by bone. Those things which we know as bony elements of the skeleton in the adult, in the embryo exist merely as cartilage, but the cartilage is not converted into bone but it is destroyed and its place taken by bone. There is overlying the heart of a child at birth a well-developed gland known as the thymus. After childhood this undergoes a retrograde development; it becomes gradually absorbed and persists only in a rudimentary condition. With the loss of the teeth occurring during infancy, you are familiar, and know that the first set of teeth are but for a short period, and are to be replaced by the permanent set. In very old persons we see a great deal of the bony material absorbed, and this absorption of the bone is a phenomenon which occurs at almost every period of the development. Portions of the epidermis or outer skin are constantly shed, as is well known, and the loss of hair and the loss of portions of our nails are so familiar to us that we hardly heed them. Of the constant destruction of the cells, which are found in the lining of the intestine, I have already spoken. At all times in the body there is a vast amount of destruction of blood corpuscles going on, a destruction which is physiologically indispensable, for the material which the blood corpuscles furnish is used in many ways. For instance, the pigment which occurs in the hair is supposed to be derived from the chemical substances the use of which the body obtains by destroying blood corpuscles. One of the most familiar instances of destruction is that of the tail of the tadpole. The young frog and the young toad during their larval stages live in the water and each of them is furnished with a nice tail for swimming purposes. As the time approaches for the metamorphosis of the tadpole into the adult, the tail is gradually dissolved away. It is not cast off, but it is literally dissolved, resorbed, and vanishes ultimately altogether.

It is evident that such a vast amount of destruction of living cells could not be maintained in the body without the body going entirely to destruction itself, were there not some device for making good the losses which are thus brought about. We find in fact that there is always a reserve of cells kept to make good the loss which it is essential should be made good. Some losses apparently do not have to be repaired, but the majority of them must be compensated for, and this is done by having in the body a reserve supply of cells which can produce new cells of the sort required. This leads us to consideration of the phenomenon of regeneration and of the repair of parts.

These phenomena we can better take up later in our course, when we have dealt with the general processes of development and growth. From the study of regeneration we shall be able to confirm the explanation of old age, which I want to lay before you. This confirmation is so important that it will be better taken up in a separate lecture, than slipped in now when the hour is nearly by.

Old age, after what I have said, I think you will all recognize as merely the advanced and final stage of cytomorphosis. Old age differs but little in its cytomorphosis from maturity; maturity differs much from infancy; infancy differs very much indeed from the embryo; but the embryo differs enormously from the germ in its cytomorphic constitution. We know that in the early time comes the great change, and this fact we shall apply for purposes of interpretation later on. Cytomorphosis is then a fundamental notion. It gives us in a general law, a comprehensive statement of all the changes which occur in the body. None, in fact, are produced at any period in any of us except in accordance with this general cytomorphic law. There is, first, the undifferentiated stage, then the progressive differentiation; next there follows the degenerative change ending in death, and last of all the removal of the dead cells. Such we may conveniently designate as the four essential stages of cytomorphosis. This cytomorphosis is at first very rapid; afterwards it becomes slower. That is a significant thing. The young change fast; the old change slowly. We shall be able, when we get a little farther along in our study, to see that in differentiation lies the explanation of a great deal of biological knowledge, lies the explanation of our conception of cell structures; and in it also lies not only the explanation of the death of cells, but also, as it seems to me—and this is one of the points that I shall want particularly to bring forward before the close of the course—of general death, that which we mean by death in common parlance, when the continuation of the life of the individual ceases, and is thereafter bodily impossible. The explanation of death is one of the points at which we shall be aiming in the subsequent lectures of the course. Now we know that in connection with age there is always growth. I propose, therefore, in the next lecture, to take up the subject of growth. We shall arrive at some paradoxical conclusions, for it can be shown by merely statistical reckonings that our notion that man passes through a period of development and a period of decline is misleading, in that in reality we begin with a period of extremely rapid decline, and then end life with a decline which is very slow and very slight. The period of most rapid decline is youth; the period of slowest decline is old age, and that this statement is correct I shall hope to prove to you with the aid of tables and lantern illustrations at the next lecture.

THE PLACE OF LINNÆUS IN THE UNFOLDING OF SCIENCE; HIS VIEWS ON THE CLASS MAMMALIA[1]

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IN order rightly to appraise the value of Karl von Linné's contributions to biological science, it is necessary to bear in mind two very axiomatic facts. Our first axiom is that Linnæus became a point of departure in the history of modern biology only because he was in turn the product of the intersection of a great number of important causal series, which ramify and intertwine indefinitely and stretch back into the remote past of every aspect of life. The second axiom is that every new idea, or, for that matter, every new event, is the fertile hybrid from the fortuitous crossing of two or more specifically distinct old ideas, or events. And in order that we may discern a few of these fortuitous crossings and follow a little some of these interminable and intricate streams of cause and effect, it may not be inappropriate, in connection with the two-hundredth anniversary of the birth of Linnæus, to touch briefly upon a series of seven epochs of thought, from Aristotle to Darwin; and further to glance at the principles and facts upon which Linnæus based his two great contributions to the broader knowledge of the class of which man is the dominating member.

Not to go back indefinitely, we begin with the Aristotelian or initial analytic epoch of the fourth century B. C. Aristotle's theory of the genetic relationship of the chain of beings from polyp to man did not, of course, materially influence Linnæus. The idea of evolution which St. Thomas Aquinas, the "princeps scholasticorum" understood and developed, was not destined to come to its fruition through the schoolmen or even in Linnæus or Cuvier. But the true relation of Aristotle's thought to that of Ray and Linnæus may be exhibited in the following well-known citations from "The Parts of Animals."[2]

> Some animals are viviparous, some oviparous, some vermiparous. The viviparous are such as man, and the horse, and all those animals which have hair; and of the aquatic animals, the whale kind, as the dolphin and cartilag-

[1] This article is here published by courtesy of the council of the New York Academy of Sciences. It is largely adapted from a forthcoming memoir by the writer on the "History of the Classification of the Mammalia," prepared under the direction of Professor Henry Fairfield Osborn.

[2] Quoted by W. Whewell, "History of the Inductive Sciences," 8vo, London, 1837, Vol. III., pp. 347.

inous fishes [in reference to the viviparity of certain sharks]. (Book I., chap. V.) Of quadrupeds which have blood and are viviparous, some are (as to their extremities) many-cloven, as the hands and feet of man. For some are many-toed, as the lion, the dog, the panther; some are bifid, and have hoofs instead of nails, as the sheep, the goat, the elephant, the hippotamus; and some have undivided feet, as the solid hoofed animals, the horse and ass. The swine kind share both characters. An allusion to the "mule footed" swine, monstrosities in which the median digits are fused and terminate in a solid composite hoof. (Bood II., chap. V.)

Ray and later writers probably had this passage in mind when they used the descriptive terms "multifido," "bifido," "solidungula," "ungulata," "unguiculata," "fissipedes." Here also attention is directed to the feet as exhibiting characteristic differences.

Animals have also great differences in the teeth both when compared with each other and with man. For all quadrupeds which have blood and are viviparous have teeth. And in the first place some are ambidental[3] (having teeth in both jaws); and some are not so, wanting the front teeth in the upper jaw. Some have neither front teeth nor horns, as the camel; some have tusks, as the boar; some have not. Some have serrated teeth,[5] as the lion, the panther, the dog; some have the teeth unvaried,[6] as the horse and the ox; for the animals which vary their cutting teeth have all serrated teeth. No animal has both tusks and horns; nor has any animal with serrated teeth either of those weapons. The greater part have the front teeth cutting, and those within broad (chap. II.).

This passage evidently directed the attention of later writers to the importance of the teeth as a means of distinguishing and hence of classifying mammals, and we shall see that Ray and, later, Linnæus were quick to avail themselves of the suggestion.

Although Whewell[7] proves that Aristotle was quite unconscious of the classification that has been ascribed to him, he also admits that "Aristotle does show, as far as could be done at his time, a perception of the need of groups, and of names of groups, in the study of the animal kingdom; and thus may justly be held up as the great figure in the Prelude to the Formation of Systems which took place in more advanced scientific times."

Whewell quotes passages that show recognition of the lack of generic names to denominate natural groups. Aristotle says that "Of the class of viviparous quadrupeds there are many genera,[8] but these again are without names, except specific names, such as man, lion, stag, horse, dog, and the like. Yet there is a genus of animals that have manes, as the horse, the ass, the *oreus*, the *ginnus*, the *innus*, and the animal which in Syria is called heminus (mule). . . . Wherefore," he

[3] Αμφόδοντα.
[4] Χαυλιόδοντα.
[5] Καρχαρόδοντα.
[6] Ἀνεπάλλακτα.
[7] *Op. cit.*, III., p. 350.
[8] Εἴδη.

adds (that is, because we do not possess genera and generic names of this kind), "we must take the species separately and study the nature of each." "These passages," Whewell continues, "afford us sufficient ground for placing Aristotle at the head of those naturalists to whom the first views of the necessity of a zoological system are due" (*op cit.*, p. 352).

It is not necessary to dwell on the fact that from the time of Aristotle and his classical successors to the close of the middle ages Europe thought itself too much preoccupied to pay particular attention to natural history; on the one hand with world-wide displacements and readjustments of peoples and of institutions, and on the other hand with the development of the great body of religious and metaphysical doctrines. Even the next epoch requiring our attention, the scholastic epoch in the history of science, so far as natural history is concerned, is perhaps rather a further interregnum than an epoch, rather an era or lapse of uneventful time, than a time of the slow ascension of some great illuminative idea. The anthropocentric idea dominated in natural history as the geocentric idea dominated in astronomy and hence a knowledge of the real or supposed properties of animals, and especially of plants, was chiefly cultivated in connection with alchemy, magic, materia medica, etc. The medieval imagination, full of mysticism, eager for the uncanny and fantastic and teeming with images of the ubiquitous devils, flourished on the marvelous tales of a "Sir John Mandeville," and peopled the earth with the monsters which so long survived and ramped in the Terræ Incognitæ of world maps. In the schools citations from authorities were accepted in lieu of proof, and the simple zoology of Aristotle and the scriptures was deeply covered by the accretions of learned exegesis.

However, it must be remembered that scholasticism had reached its prime as far back as the thirteenth century, in the system of the illustrious St. Thomas Aquinas, and that while the renaissance movement was discovering new worlds in all directions, scholasticism in general (but with some brilliant exceptions) had reached the phylogerontic stage, and was producing all sorts of bizarre specializations in terminology and in dialectic.

Nevertheless, it can not be doubted that the very excesses of scholasticism stimulated the reactive return to experience, which gave rise incidentally to biological science. Furthermore, the schoolmen perpetuated and aroused interest in Aristotle's analyses, and gave currency to many methods of analysis and description. Among these we may cite the dichotomous method of division, which is a forerunner of modern classifications, and the logical concepts of genus and species. Especially noteworthy was the expansion of classical Latin into a highly specialized language of philosophy and science.

We now come to the renaissance epoch. Biological science, and especially zoology, did not respond fully to the impulse of the renaissance movement until literature, politics, astronomy and geographical discovery had made the most signal advances. Hence in Aldrovandi (1522–1605) and Gesner (1516–1565) the superstitions and myths of the middle ages still linger, while the systematic work of future generations is initiated in the extensive, illustrated catalogues and descriptions of plants and animals. On the philosophical side of zoology, the Englishman Wotton, in his "De Differentiis Animalium" (Paris, 1552,) "rejected the legendary and fantastic accretions [of medieval zoology] and returned to Aristotle and the observation of nature" (Lankester).[9] One of the contemporaries of Gesner and Wotton was the founder of anatomy, Andreas Vesalius (1514–1564), who boldly broke with tradition and declared that the source of knowledge of the human body should be not Galen, but the human body itself.

Near the end of this period, the botanist, Cesalpino (Cæsalpinus), of Arezzo (1519–1778), himself a celebrated scholastic philosopher, but animated also by the new idea of direct observation, published his voluminous work "De Plantis" (1583). In this work the confused arrangements of plants of the earlier herbalists are replaced by an orderly classification suggested by the brigades of an army, and founded upon the number, the position and the figure of the reproductive parts. He divided plants into ten great classes, which were again subdivided; to these assemblages he gave monomial names in substantive form. Linnæus says of him that, "though the first in attempting to form natural orders he observed as many as the most successful later writers." (Whewell, *op. cit.*, pp. 282–283.)

We may venture to suggest as a reason for this precocious development of a natural classification of plants the very multiplicity of kinds and the large herbaria and horticultural gardens in existence which necessitated some sort of orderly arrangement, and which would assist the eager student to recognize related series. We note in contrast the delayed progress of the classification of the mammals due to the comparative fewness of known forms, the greater complexity of organization and the difficulties of observation.

Among those who contributed the data for Linnæus's generalizations, no name is more important, at least in the history of vertebrate zoology, than that of John Ray. Accordingly, the fourth epoch under consideration may be termed the Raian epoch, and culminates with the publication in 1693 of Ray's "Synopsis Methodica Animalium Quadrupedum et Serpentini Generis," which is one of the great landmarks in the history of classification. Ray's debt to the past is shown in the

[9] Lankester, E. Ray, The History and Scope of Zoology, in "The Advancement of Science," London, 1890, p. 293.

facts that his very lucid tabular analyses of the common structural features of animals are arranged dichotomously, that in each division and subdivision a single adjective or adjectival phrase indicates the most important common feature of the animals in question, and that these terms are, as we have seen, in many cases borrowed from Aristotle.

Ray, like Linnæus, gave more attention to plants than to animals, and depended upon his colleague, Willughby, for much of the data, especially in the fishes. And, like Linnæus also, Ray had a superb gift of order and a philosophical mind that made him a worthy countryman and contemporary of Sir Isaac Newton.

In his tabular analysis Ray distinctly foreshadows Linnæus in the following points:

1. The higher vertebrates are contrasted with the fishes as breathing by lungs instead of gills.

2. The whales are classed with the viviparous animals and expressly removed from the fishes, from which they were further distinguished by the horizontality of the tail fin. This step, however, was felt to be so radical that Ray afterwards constructed a definition which included both whales and fishes.

3. As remarked by Gill, the terrestrial or quadruped mammals are bracketed with the aquatic as "Vivipara," and contrasted with the "Ovipara" or "Aves." "The Vivipara are exactly coextensive with Mammalia, but the word vivipara was used as an adjective and not as a noun. Linnæus did not catch up with this concept till 1758, when he advanced beyond it by recognizing the group as a class and giving it an apt name."[10]

4. The double ventricle is noted as characteristic of both Vivipara and Ovipara.

5. In order to associate the "Manati" and other amphibious mammals with their terrestrial congeners the term "hairy animals" is employed as more comprehensive than quadrupeds.

Ray further set the standard for Linnæus in his concise descriptions of European and foreign mammals, especially those described by travelers in America and in the east. Ray often used the term "species" merely as the equivalent of the middle English "spece," which survives in our word "spice," and meant "kind"; it was also equivalent to the logical "species (*cf.* the Greek εἶδος) of the schoolmen and is exemplified in Ray and Willughby's "Historia Piscium" in such phrases as "clarias niloticus Belonii mustelæ fluviatilis," "bagre piscis barbati ac aculeati species." But Ray also used the term species in quite a Linnæan manner, as in the names *Ovis laticauda, Ovis strepsiceros, Ovis domestica,* etc. In form, at least, this foreshadows the binomial sys-

[10] "The Story of a Word—Mammal," POPULAR SCIENCE MONTHLY, Vol. LXI., September, 1902, pp. 434–438.

tem of nomenclature and the recognition of the species in general as an objective reality and the unit of classification. But the form of Ray's specific definitions seems to imply that the term "species" in Ray's mind was often more a "differentia," or specific adjective modifying the generic concept, than a fully-developed substantive name, and Ray did not apparently realize the convenience of applying the binomial method of nomenclature universally. Even Linnæus at first introduced the specific, "trivial," or common, name, merely as a marginal index or symbol of the full specific phrase. Ray recognized the considerable variability of species but believed also in their separate creation and fixity. Ray frequently adverts to the internal characters of animals, and even a cursory examination of his book shows that, even by his time, a considerable number of observations on the soft parts of animals had already accumulated.

The work of Ray in botany and zoology fully prepared the way for Linnæus himself, whose epoch may be designated as the Linnæan or legislative epoch, because in his time methods of description, of classification and laws of nomenclature became fully established and settled. Linnæus inherited from Ray and from the scholastic system, the dogma of the separate creation and objective reality of species which became developed and strengthened in his hands as a result of his observations. His dictum was "species tot sunt diversæ quot diversæ formæ ab initio sunt creatæ." The resemblance between members of a single species were hence held to be due to descent from an original pair, and the mutual infertility of species to be the natural penalty of the effort to traverse the gaps established from the beginning.

And now that we have traced briefly the steps leading up to Linnæus, a few words more will summarize the relation of Linnæus to his successors. The sixth epoch in the history of zoology extends from the latter part of the eighteenth to the middle of the nineteenth century, and may be called the anatomical epoch, because, through the labors of Cuvier and his great English pupil and successor, Richard Owen, the taxonomic studies of the Linnæan school were supplemented by the establishment and great development of the sciences of comparative anatomy and paleontology. Cuvier's researches in these sciences further extended the dogma of the fixity of species, but Owen, through his broader knowledge, gradually gave up the idea and became an evolutionist, although not a selectionist. The seventh epoch, the Darwinian, in which happily we are living, has seen the overthrow of the traditional doctrine of the fixity of species, and has initiated the reexamination of all cosmical and terrestrial phenomena in the light of the doctrine of evolution.

Thus the great lawgiver of natural history is seen in his proper perspective, inheriting, on the one hand, the language and

general methods of the past and the doctrine of special creation; inheriting, on the other hand, the new spirit and contributions of Vesalius, Cesalpino, Ray and many others, and building upon this the foundations of modern botany and zoology.

In attempting to appraise Linnæus's contributions to the broader knowledge of the class of mammals, we must bear in mind what Dr. J. A. Allen has well shown, namely, that Linnæus was primarily a botanist, that his interest in mammals was incidental, his opportunities for studying them very limited and his first-hand knowledge of extra-European mammals practically *nil;* and finally that several of his ordinal groupings of mammals (*e. g.,* rhinoceros with the rodents) now appear highly unnatural and even ludicrous. But there are certain considerations which may prevent us from thinking any the less of Linnæus's judgment and genius on that account.

Although Linnæus may have known very little about extra-European mammals, he had, nevertheless, a fairly good conception of the essential features of mammals as a class, as shown by his definition in the tenth edition of the "Systema Naturæ" (1758). Here in concise phrase he states that mammals have a heart with two auricles and two ventricles, with hot red blood, that the lungs breathe rhythmically, that the jaws are slung as in other vertebrates, but "covered," *i. e.,* with flesh, as opposed to the "naked" jaws of birds; that the penis is intromittent, the females viviparous, that they secrete and give milk, that the channels of perception are the tongue, nose, eyes, ears and the sense of touch; that the integument is provided with hairs, which are sparse in tropical and very few in aquatic mammals; that the body is supported on four feet, save in the aquatic forms, in which the hind limbs are said to be coalesced into a tail (the only erroneous idea in the whole definition).

Many of these characters had previously been noticed by Ray in his description of the hairy quadrupeds; and it is not impossible that Linnæus may have been assisted to the comprehension of the essential features of the mammals through his friendship with Bernard de Jussieu, who is said by Isidore Geoffroy St. Hilaire to have induced him to include the Cetaceans in the class Mammalia; and possibly he owed something to the researches of Klein and Brisson. But Linnæus's own studies in medicine, in Holland, doubtless made him familiar with the anatomy of at least one mammal, man, and on his journeys through the north of Europe he must have observed many mammals at close range.

All this prepared him for the clear recognition and emphasis of two facts of far-reaching importance. It was evidently well known

that the anatomy of mammals was similar in plan, if not in detail, to that of man, and we find Descartes, for example, in his "Discourse on Method" (Part V., 1637) advising those who wished to understand his theory of the action of the lungs and circulatory system, "to take the trouble of getting dissected in their presence the heart of some large animal possessed of lungs, *for this is throughout sufficiently like the human*" (*ital. mihi*). And it was further known that of all animals the monkeys are most nearly like man, both externally and internally. This was asserted by Aristotle and other classical authors but was fully demonstrated in a carefully prepared and illustrated work[11] on the anatomy and appearance of animals from the Jardin du Roi, by a committee of savants of the French Academy, appointed by the Grand Monarch.

That this work and these important facts came under the notice of Linnæus on the occasion of his visit to Paris in 1738 is not improbable. At any rate, Linnæus did not hesitate to follow the logical consequences of these facts, namely, that in a strictly zoological classification man would be grouped not only in the class mammalia, but even in the same ordinal division with the monkeys. Accordingly, in the tenth edition of the "Systema" the earlier name Anthropomorphæ is replaced by Primates, and the genera *Homo, Simia, Lemur, Vespertilio* are grouped under that order. The Primates were thus regarded as the chiefs of the graded hierarchy of terrestrial beings, and consequently, as in nearly all subsequent schemes down to the Darwinian epoch, head the classified legions of creatures. This allocation of man to the order Primates was surely an instance of Linnæus's genius in surmising the true affinities of puzzling organisms, and led the way to the modern generalization that man is knit by ties of blood kinship to the Primates, and more remotely to the whole organic world.

The diagnostic definition given by Linnæus of the order Primates may be cited because it rests upon the principles and theories which guided him in classification and which led to his most successful groupings, as well as to his serious blunders. This definition is as follows:

Inferior front teeth iv, parallel, laniariform [canine] teeth solitary [*i. e.*, in a single pair].
Mammæ pectoral, one pair.
The anterior extremities are hands.
The arms are separated by clavicles, the gait usually on all fours ("incessu tetrapodo volgo").
They climb trees and pluck the fruits thereof.

That this definition was insufficient to exclude all extraneous genera from this really natural order is evident from the facts: (1) That under

[11] "Mémoires pour servir à l'Histoire naturelle des Animaux," à la Haye, 1715 (4to, 2 vols.), Redigées par Perrault et Dodart.

Lemur Linnæus included not only all the then known forms now recognized as the suborder Lemuroidea, but also the "Flying Lemur" *Galeopithecus,* which properly either forms an order by itself with no near affinities with the Primates, or is at most a suborder of the Cheiroptera. (2) The definition also included the bats (*Vespertilio*), an order more nearly related to the Insectivores than to the Primates.

Many of the characters selected by Linnæus for his ordinal diagnoses were of the "adaptive" or superficial kind which are now known to have been most easily modifiable by changes in the external or internal environment. The reason for this mistake (a mistake from which few naturalists were free even down to our own generation) was that Linnæus regarded the mode of sustenance of a group as one of its most deep-seated attributes, most surely indicative of more or less hidden affinities with other groups. For it is well known that Linnæus was constantly searching for natural groups, although he did not realize that the natural affinity of the members of the larger groups was due to descent from common ancestors, just as in the case of members of the same species. An example of his reliance upon sustenance is seen in his definition, in the tenth edition of the "Systema," of the order Feræ, the Carnivora of later authors. Here "sustenance by rapine, upon carcasses ravenously snatched" is evidently felt to be connected with "front teeth in both jaws: superior vi, all acute," with "laniariform teeth [canines] solitary," with "claws on the feet acute." But one of his dicta in botany was that a character of great systematic importance in one group may be very variable in another, consequently he did not mention sustenance under Bruta, but contented himself with the two characters "front teeth none either above or below" and "gait awkward (*incessus ineptior*)." As this order included the elephant, the manatee, the sloth, the great anteater and the scaly anteater, it has been justly cited as a grossly unnatural assemblage; and the grouping accounted for by Linnæus's ignorance of the animals composing it. But I am more disposed to attribute it first to his habit of searching for hidden affinities below the most obvious external differences, as when he placed the seals in the order Feræ, joined the bats with the Primates, the horse and the hippopotamus, the rhinoceros with the Rodents, and the pig with the Insectivores (in the order Bestiæ). That Linnæus recognized that the ordinal classification of the mammals was a difficult problem is shown by the conspicuous changes (not always improvements in our eyes) and redistributions which he made between the first and "tenth" editions of the "Systema" and further by the fact that Erxleben who revised and extended the Systema (1777) abandoned the ordinal divisions entirely and merely listed the genera seriatim. The difficulty of the problem in indi-

cated by the fact that Cuvier, with far better material and more extensive knowledge, was constantly deceived by "adaptive" (or homoplastic) resemblances, and that even Professor Cope, who wrote much on homoplastic and convergent evolution, was himself deceived by the similarities of structure in the Marsupial "mole," *Notoryctes,* and the Cape Golden mole (*Chrysochloris*), an undoubted Insectivore. Furthermore, that even the most "inexcusable" blunder of Linnæus, that of placing rhinoceros with the Rodents under the order "Glires," was due, not to carelessness, but to the fact that the Indian rhinoceros has a single pair of close-set cutting incisors in the upper jaw which oppose the elongate incisor-like appressed canines of the lower jaw, and thus show a superficial approach to the Rodent dentition. If Linnæus had known that *Hyrax,* which Pallas described as a Rodent (*"Cavia"*), had cheek teeth like those of *Rhinoceros,* he doubtless might have felicitated himself upon his supposed astuteness.

In brief, Linnæus (as fully shown by Whewell[12]) from his profound and wide botanical knowledge, was acquainted with many natural orders and strove constantly to recognize others; he knew that a character of great diagnostic and fundamental value in one order may be of slight value in another; he knew that even in a natural order some of the diagnostic and fundamental characters might be absent in certain members otherwise clearly allied to a given series. He knew that a natural series is natural because of the totality of its characters, that the "genus makes the character" and not *vice versa*—a hard doctrine to many of his contemporaries. And when he had arrived at a conception of any given natural order he selected certain characters as diagnostic but not necessarily universal, and constructed professedly artificial or only partially natural keys to his "natural" orders.

Thus we may believe that when Linnæus turned his attention to the classification of animals he followed the same principles. And in this application of the principles gained in one subject to the data of another, we have a good example of the felicitous union of specifically distinct ideas to produce a line of ideas that were new and very fertile.

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[12] *Op. cit.,* pp. 319–325.

RECENT LEGISLATION ON THE MISSISSIPPI RIVER

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THE new River and Harbor Bill is of particular interest in the portion pertaining to the Mississippi River. For over twenty years levee construction and maintenance has been the dominant feature of the river's regulation. During nearly half that time a concerted effort has been made to maintain a navigable channel when the river is at a low stage. There are indications that the catchword for the years to come will have reference to a 14-foot waterway from the lakes to the gulf. In the original act[1] three lines of procedure, one a continuation of former projects, the other two in some wise new projects, were advocated. Briefly, these are as follows:

1. An appropriation for the general improvement of the river, for the extension of the levee system and for the improvement of navigation. This includes the maintenance of a navigable channel of at least 200 feet in width and 9 feet in depth from Cairo to the Gulf.

2. An appropriation for the improvement of the river from the mouth of the Ohio River to the mouth of the Missouri River. This appropriation is a reduction of the sum appropriated in the last River and Harbor Bill.

3. The appointment of a board to report upon the practicability and desirability of constructing a navigable channel 14 feet deep and of suitable width from St. Louis to the Gulf, either by improvement of the river or by a canal or canals for a part of the route.

The first of these continues the work under the control of the Mississippi River Commission, a board created in 1879. This board has defined the law which created them in the following general terms:[2]

1. Continuation of surveys; preparation and publication of maps, maintenance of gauges; the recording, tabulating and publication of gauge readings; the taking and recording of discharge measurements at high and low stages of the Mississippi River and its tributaries, and other observations.

2. The building, extension and repair of levees.

3. The building, maintenance and operation of dredge boats.

4. The repair and extension of existing works for the improvement of the channel, the preservation of harbors, the prevention of cut-offs, and the security of levees.

5. The maintenance of a low-water channel between the Mississippi, Red and Atchafalaya Rivers.

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[1] H. R. 24991. An act making appropriations for the construction, repair and preservation of certain public works on rivers and harbors and for other purposes.

[2] Report of the Mississippi River Commission for the fiscal year ending June 30, 1906, p. 2470.

Although the history of the confinement of this river covers a period of nearly 200 years, no concerted plan for the regulation of the river in its extent through the alluvial basin had been attempted. The commission took up its work at a peculiarly fortunate time. The organization was about completed when, in 1882, a flood of unprecedented size overflowed the whole alluvial basin and destroyed most of the levees then existing. The slate was clean. No previous work conceived along narrow lines blocked the progress of any project which the commission might formulate. The land owners and riparian proprietors were discouraged. Their work in levees was destroyed and burdensome taxes for levee construction had profited them little. The allotments of money appropriated by the government revived their spirits and renewed efforts were instituted. Levee construction has gone on continuously from that time to the present, until to-day a little less than 75 per cent. of the banks of the river south of Cape Girardeau, Mo. is leveed. The recommendations of the commission show that the early completion of the system of levees is in their opinion a desideratum. The levees have been constantly increased in height. This was expected. The confinement of waters within narrower and narrower limits as the levees increased in length would be evidenced in the vertical expansion of the waters. There is no criterion for the height of the embankments except the highest known stage of the river. It is planned to exceed this stage by from 2 to 4 feet. The difficulties of this arrangement may be illustrated by the floods of 1897 and 1903. A provisional grade 2 feet above the 1897 flood was adopted; in 1903 the flood was in some places 2.5 feet above the 1897 stage and the waters would have over-topped the levees had they not been reenforced by sand bags. After the 1903 flood a new provisional grade was adopted which in some instances is 5 feet above the provisional grade for the years before. There always remains the possibility, and it is not a remote one, that the highest-known flood may be exceeded in stage.

That the constructions and vigilance of the men working under this commission have been effective, the showing of the Yazoo Basin proves. This basin, having an area of about 6,300 square miles, equivalent to the combined areas of Connecticut and Rhode Island, has in twenty years experienced an increase of over 100 per cent. in its population. In 1900, 195,346 people were living in this area. Railroads have been built, forests have been removed, lands cultivated, industries of many kinds developed and holdings of scarcely a nominal price have become farms of considerable value.

That protection has not always been accorded the dwellers of this and other basins is also evident when the records of flood seasons are reviewed. In the Yazoo Basin during the high water of 1903, the last high water season, one fourth of the basin was under water; one half of the city of Greenville inundated; 60,000 people, or one third of the inhabitants of the basin, driven from their homes, and traffic was sus-

pended on the railroads, on the Yazoo and Mississippi Valley Railroad for twenty days and on the Riverside Division for forty days. There was no loss of life or of live stock and most of the movable farm implements and machinery were saved. For this protection from loss a great share of the credit should be given to the Weather Bureau, which sent out warnings to the inhabitants of the basin a few days before the river reached its highest stage.

Another line of work in charge of the commission is the maintenance of a navigable highway from Cairo to the Gulf. The specifications demand a channel of at least 200 feet in width and 9 feet in depth. To meet this demand, a number of dredges have been constructed, and as fast as the river falls in stage and approaches a 9-foot depth dredging operations are inaugurated. It has been proved that, unless the river falls to an abnormally low stage, it is altogether within the power of the dredging parties to maintain the required size of channel. Notwithstanding this surety and this success, the traffic of the river has declined in volume during the last thirty years. This decline may be due to a number of causes. The greater length of the waterway over the railway between the same ports resulting from the meandering of the river, and the greater speed attainable in rail traffic make the time by rail to the time by water from St. Louis to New Orleans as 1 to 10. A second disadvantage of the water route lies in its uncertainty. During high water stages navigation is difficult. At times the boats are ordered to go at slow speed lest the wash increase the caving of the levees. There is also an uncertainty concerning the location of the low-water channel. Even with the success of the dredging operations the channels are often difficult and hard to run. A third cause which is emphasized by the loss of time and the uncertainty of the passage is the constantly decreasing difference between the tariffs by rail and by water. A fourth cause lies in the active part which railroad companies have taken in the competition.

A liberal appropriation is made for the continuance of the work of the parties under the direction of the River Commission. While different judgments concerning the efficiency of their work prevail, the opinion is a general one that this work ought to be prosecuted until a more obvious means of benefiting the people of the alluvial basin and at the same time serving the needs of the inhabitants of the valley can be devised.

The second point in the River and Harbor Bill was an appropriation of $250,000 for the stretch of river between the mouth of the Missouri and the mouth of the Ohio. The Senate amendment to this portion of the bill was a complete renovation with an appropriation of $650,000. It was later understood, however, that the Senate conferees had yielded to the argument of the House conferees and would allow the amendment to be stricken from the bill. During the four seasons just past this stretch of river has had an appropriation of $650,000 annually. In

1897, the appropriation was $673,000; in 1903, $758,000. The debate upon this reduction was long and brought out some interesting statements. The reasons for this reduction may be summed up as follows:

1. There has been a continual falling off in the traffic along this stretch of river. While the projected 8-foot channel has to a large degree been maintained, at no time has the improvement of this portion of the river been reflected in the traffic. Altogether there has been spent on this portion $12,000,000, and the traffic last year was only about 440,000 tons. This tonnage of traffic does not include ferriage, which is little affected by river improvements.

This loss of traffic was explained by the citation of conditions which are similar in the Kansas-St. Louis stretch of the Missouri River. When the boats began to get the business between these two cities, the railroads paralleling the river organized a determined opposition. The roads acted concertedly and reduced the tariff rates along this stretch of river to one third the former scheduled rates. They were reported to have gone even further. They went out and under-bid the boats. Gradually the stock in the boat lines passed from the hands of the promoters, and competition ceased. The old schedule of railroad rates was then resumed. It is also suspected that the rebate system until recently in vogue between large shippers of freight and the railroad companies acted against the river traffic. Along the Cairo-St. Louis stretch of the river, the building of boats ceased in 1893, and a constant reduction of the fleet has gone on since that date.

From	To Memphis			To New Orleans			To St. Louis	
	A	B	C	A	B	C	A	C
Clarkesdale	76.7	$1.25	$0.56	378.9	$2.25	$0.72	390.1	$1.21
Friars Point*	70.1	1.00	.45	385.5	1.00	.45	383.5	.90
Cleveland	113.6	2.00	.62	342.0	—	—	—	—
Rosedale*	114.0	1.25	.45	341.6	—	—	—	—

* On Mississippi River.

A, distance in miles; B, cotton per bale; C, first-class merchandise per 100 pounds.

It is claimed, however, in rebuttal that it is immaterial whether the tonnage is actually floated on the river or not. The means of cheap transportation is gained if the riverway is open to traffic. Two illustrations of this follow. It is about the same distance from St. Louis to three Mississippi towns, Greenville on the Mississippi River, Greenwood on the Yazoo River and Winona, inland. The freight rates by rail to these towns are, to Greenville, $0.90 per one hundred pounds, to Greenwood, $0.96, and to Winona, $1.14. In other words, the improvement of the river from St. Louis to Greenville and to Greenwood has accomplished the ends desired, even though the transportation has to a large extent been by rail. A still clearer case is made out in the preceding table.[3]

[3] Congressional Records, Vol. 41, 2427, February, 1907.

2. The engineers have not agreed concerning the works along this stretch of river. They have been at "loggerheads." Furthermore they could not spend the annual appropriation of $650,000. At the end of the fiscal year in 1905 it was reported that there was a balance on hand of $915,000.

3. The proposition of a deep waterway (14 feet) from Chicago to New Orleans *via* this stretch of river affected the appropriation. If this 14-foot waterway is attempted it seems to be the feeling that the depth in some portions, if not all, of this stretch of river between St. Louis and Cairo would have to be obtained by a lateral canal. It was not prudent to allot money for permanent improvements as long as a change of policy was imminent. It is claimed that the reduction of the appropriation is not hostile to this portion of the river nor to the proposed 14-foot waterway. It is a temporary halting of work in order to await the development of other projects and to give the engineers time to study the problems further in the hope of a closer approach to unity of recommendation.

The third section of the River and Harbor Bill pertaining to the Mississippi River had reference to very extensive improvements of the river and had for its main clause the consideration of a 14-foot waterway from St. Louis to the Gulf. The realization of such a waterway with the completion of the project, already instituted, of a 14-foot waterway from Chicago to St. Louis will give a deep waterway from the sea to the Great Lakes. There is little opposition to such an undertaking. It is generally admitted that a highway of this nature would prove of great value to the country as a whole. The immediate need of this waterway arises from the fact that the products of the valley have outstripped the carrying capacity of the railroads. It has been admitted by railroad men that there is no promise of greater transportation facilities, and that the construction of new lines, of new cars and engines, can not keep pace with the increasing output of mills, plains, forests and mines. The only relief to this congestion seems to lie in the Mississippi River. The regulation of this stream up to the present day has not been of such a nature as to greatly benefit the producers and give them a highway for their output.

While it is generally conceded that all this is true, the proposition for the regulation of the river has been accompanied by plans of so visionary a nature that many people have withdrawn for a season their support or have cast their lines in opposition. This section of the River and Harbor Bill carried with it no feature to which objection should be taken. It plans for a thorough inspection of the problem of a deep waterway by a competent committee. This committee is directed to report to congress on the feasibility of such a waterway. Its duty is one of investigation, not of operation. We may expect a careful consideration of all the problems pertaining to a deep waterway and such recommendations as they see fit to make. There is in the specifica-

tions drawn up for this committee a clause which requires them to report upon the possibility of using locks and dams similar to those in use on the Ohio; in other words, to ascertain whether the canalization project is feasible for the Mississippi River. It is this project of canalization which has aroused opposition. Some of the proposers of this plan of improvement, and they were probably the instigators of this section of the bill, have advocated canalization as the only means of obtaining the requisite depth of channel. It is but just to assume that the business men of the valley, and especially the St. Louis contingent, have a definite and well-considered plan for gaining a deeper waterway. At the same time it is unfortunate that their desires should have been introduced to the general public as an undertaking of stupendous magnitude and a work which the public would be forced to promote. An extravagant speech in congress which pictured the bounds of a canalization plant as "two granite walls, 200 feet high and 2,000 miles long" in comparison with which the Chinese wall "7 feet high and only about 450 miles long" is diminutive, was probably no more excessive than the terms by which the speaker may have been informed of the project.

The canalization of a river is not a new method of benefiting the navigable quality of a river. Many streams in Europe, as the Elbe, Seine and the Main, and some streams in this country, portions of the Ohio, for example, have been regulated successfully by this method. The canalization of a stream turns the river into a series of steps; passage from one step to the next higher or lower is made through a lock, and the height of water is sustained by a dam across the main channel of the river. The stream-flow is thus blocked and navigation is as easy up-stream as down. The best arrangement of dam and lock is possible when an island divides the stream into a main channel and a chute. If the dam or weir is located in the main channel and the lock in the secondary channel, high-water stages are not as likely to impair the locks. The weir, however, must be made movable so as not to oppose the flood force. This, in brief, is the process of canalization. While the projectors of this plan for the Mississippi River have not definitely stated what type of canalization plant they advocate, there are certain features which above others must enter into the consideration of every project of a serious nature. A few of the most salient of the characteristics I desire to mention, and, without taking issue with the promoters of canalization, to point out, here and there, the probable effects of these on canalization works.

The discharge of the river is enormous. The potent factors in river discharges are the precipitation of rain over its basin and the porosity of the soil of the basin. The Mississippi River system drains about one third of the United States. The annual discharge of the river is greater than the combined annual discharges of the Po, Danube and the Rhone. This body of water fluctuates in its flow from a flood stage in the spring to a low-water stage in the autumn. The difference in height between

these stages is commonly 50 feet. Any works in the river must be strong enough to withstand the enormous body of water of the flood stage. The locks in the chutes or side channels within the highwater levees will be inundated. The movement of the water must cause scour; and weirs, locks and abutments leading thereto would be threatened with imminent destruction.

The ratio of sediment carried by the river to the stream discharge is large. Much of this sediment is rolled along the bed of the river in waves transverse to the direction of stream flow. It is estimated that the total amount of sediment yielded to the Gulf yearly is a little over 400,000,000 tons. Enormous quantities of sediment find a temporary lodging place during the low-water season along the bed of the river. It is because of this sediment that the present dredging project is extant. It is admitted by the enthusiasts for canalization that the sediment would be injurious to a canal plant. They offer as a remedy the removal of the sediment by catchment basins before the navigable portions of the river are reached, or the removal of the sediment from the tributaries by some similar process, or the retention of the 400,000,000 tons of sediment "in the townships where it belongs." Any one of the remedies mentioned means a task as great if not greater than the original project. Catchment basins are easily constructed in small streams, but to suggest such a thing for large streams with a variable flow, the Cumberland and Tennessee Rivers for example, is to gamble with success. The retention of the sediment" in the townships where it belongs" is visionary. Some of the sediment comes from the caving banks of the river itself. This could not be eliminated. Furthermore, if the stream is deprived of much of its sediment, the power which ordinarily is expended in carrying its load can then be spent in further scour of its banks. Thus, to some degree, the deprivation of sediment will work to the harm of the protective levees.

A flood often falls rapidly in stage. During a sudden drop, the waters dump quantities of detritus along the bed. If we deny that during flood stages the sediment can be removed from the tributary streams, we must have fear for the effect of the sudden falls in river stage. Because of the resistance offered by any construction in the flooded stream, sand would tend to accumulate about such works. It is subsequent to these sudden falls that the dredging corps has to exert its utmost power in order to maintain the nine-foot depth of the dredging project. The removal of the sand from the wiers and locks would not necessarily last throughout the low-water season. Oftentimes secondary rises of the river occur which move the sand waves down-stream and obscure the trace of any previous work in dredging. Canalization, furthermore, would not make unnecessary the dredging plant. It is likely that as large a plant would be required. Dredging is carried on in the canalized rivers of Europe.

The river is long and tortuous. It has a width varying from one-

half mile to a mile. The distance from Cairo to the sea is about 600 miles; there are over 1,700 miles of river in this distance. A meander of the river adds from twelve to twenty-five miles to the length of the river, with but a mile or two of gain in distance towards the sea. The current of the river is directed alternately against the banks of the stream. Scour and caving result and sediment is added to the river. The change of locality of the river current thus engendered must be stopped in order to make the expensive canalization works other than temporary constructions. To stop this scour, dirt levees and brush revetments will not suffice. It means more solid walls on both sides of a very long river. It means an enormous appropriation and years of labor. The width of the river will add to the item of expense. A thoughtful person would deliberate and weigh carefully all the factors bearing upon the problem before advocating such an expenditure as this plan contemplates, even if he were absolutely sure of the ultimate success of it; and success in this canalization project, from our present knowledge, is not so to be rated.

It is comforting to know that procedure in this enterprise is to be slow, and that there will be time and money for a detailed study of the problem, and an opportunity for a thorough consideration of the report of the investigating committee before the country is harnessed to any definite system of regulation. There may be a call for haste as far as the immediate needs of the people of the valley are concerned. However, whatever system is inaugurated can only be begun to-day, will take years for the fulfillment and should endure for a long time. We have the assurance, furthermore, of a thorough agitation of the whole inland waterway question. In compliance with the request of numerous commercial organizations of the Mississippi Valley, the President has appointed an Inland Waterways Commission. This commission is directed to investigate the problems of inland waterways and to report with recommendations upon the problems relating thereto.

There is in the present River and Harbor Bill, in the portion relating to the Mississippi River, and in the appointment by the President a promise that the United States has instituted a more comprehensive plan than has up to this time been possible. Much of the debate on the River and Harbor Bill had back of it the sectional spirit, the demands of a locality upon its representative in congress. There is room for a larger view of river regulation than the satisfying of constituents; and the new Inland Waterways Commission can gain for us no greater boon than to infuse the states with the spirit of cooperation in place of that of rivalry.

THE DEVELOPMENT OF TELEPHONE SERVICE

BY FRED DELAND
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XIII. THE PARENT BELL COMPANIES

IT will be recalled that in the circular announcement sent out early in May, 1877, the essential text of which was reproduced in Chapter IV., the owners of the Bell patents style themselves 'the proprietors of the telephone.' These 'proprietors' in the beginning were Alexander Graham Bell, of Boston; Gardiner Greene Hubbard, of Cambridge, and Thomas Sanders, of Haverhill, each of whom held a one third interest. Then these gentlemen arranged to secure the services of Thomas A. Watson, who as a young mechanician and electrician in the Williams' shop had assisted in many of the early experiments, had made some of the early telegraph and telephone apparatus, and was familiar with Graham Bell's hopes and plans concerning the transmission of speech. In return for devoting all his time to the promotion of telephone interests, Mr. Watson received in lieu of cash payments a one tenth interest in the Bell patents. This reimbursement for services to be rendered had little tangible value at that time, but three years later could easily have been sold for more than a hundred thousand dollars. Under this arrangement Bell, Hubbard and Sanders each held a three tenths interest and Watson held one tenth.

The appearance of that first telephone circular combined with the appointment of active special agents, working on a liberal commission basis, gradually created a demand for telephones for use on private lines and for experimental purposes, and it soon became evident that quite a sum of money would have to be expended in manufacturing and delivering these instruments. But so little faith had capitalists in the future of the telephone, that it is said that Mr. Hubbard found it very difficult to raise sufficient funds to float the telephone. Thus, with a view to simplifying the conditions under which the necessary funds could be secured and the interests of the proprietors protected, on July 9, 1877, Mr. Hubbard was made trustee of the patents and empowered to exploit them for the best interests of all concerned. In turn he formed an association or partnership arrangement, "for the purpose of manufacturing and introducing said telephones into general use throughout the United States." This association was composed of only seven members during its entire life, and its affairs were managed in behalf of these seven beneficiaries by officials of their selec-

tion. The title of the organization was the Bell Telephone Association; it was not incorporated and had no capital stock, but on August 1, 1877, beneficiary certificates were issued as follows:

Gardiner Greene Hubbard	1,387	shares.
Gertrude Hubbard (Mr. H.'s daughter)	100	"
Charles Eustis Hubbard (Mr. H.'s brother)	10	"
Alexander Graham Bell	10	"
Mabel Hubbard (Mrs. A. G.) Bell	1,497	"
Thomas Sanders	1,497	"
Thomas A. Watson	499	"
Total	5,000	shares.

The active career of the association dates from August 1; Mr. Hubbard served as trustee, Mr. Sanders as treasurer, Mr. Watson as electrician, and an office was opened in room 13 in the Sears building in Boston.

Two days after the patents and property had been assigned to Mr. Hubbard as trustee, that is on Wednesday, July 11, 1877, Graham Bell and Mabel Hubbard were united in marriage at the home of her parents in Cambridge, and his wedding gift to his beautiful bride was his entire three tenths interest in the telephone patents. Thus it was to Mrs. Bell that the certificates of the association and the shares of the parent company's stock were issued when those incorporated bodies were organized and when they gave stock certificates in exchange for certificates previously issued.

Shortly after the wedding the bridal couple left for England and a tour on the Continent and did not return to this country until August, 1878. In London on October 31, 1877, Graham Bell delivered his often-quoted lecture before the Society of Telegraph Engineers, in which he detailed the researches made by himself and many others in the effort to solve the problem of telephonic transmission of sounds and speech, beginning with those of Dr. Page in 1837.

From the date of his departure to England, Graham Bell was in no way connected with the exploiting or the financing or the management of the telephone in the United States. He was the consulting electrician of the early companies, and earnestly strove to solve the technical problems brought to his notice. But while he held very liberal views on the question of local organization, he did not believe in cheap construction, nor in the use of temporary expedients that could only bring the system into disrepute and hamper and delay the introduction of good telephone service.

As already stated, following the organization of the Bell Telephone Association, the exploitation of the telephone was systematically pushed throughout the United States. This involved far greater labor and outlay than would now seem necessary to introduce so valuable a public utility. For the openly expressed skepticism of capital had to be overcome, the groundwork of a new industry had to be laid, plans for the

granting of territorial rights under equitable conditions had to be formulated, methods had to be devised for the establishment of central telephone exchanges, then equitable conditions planned for connecting neighboring exchanges with toll lines, and, finally, the invention of accessory telephone equipment and its economical manufacture and reasonable marketing. To-day there are many who believe they can tell far better how to plan these things than the parent Bell is now doing. But in the pioneer days there was no wealth in the treasury or in prospect, and there were none who were competent to advise intelligently on technical telephone questions, or to share practical telephone experience, while there were many very intelligent men who did not hesitate to discourage the movement in every way; for they could not perceive how speech transmission could have any commercial value. Yet, notwithstanding all these discouraging conditions, a careful study of the plans under which licenses were granted for operating exchanges and for toll lines interconnecting exchanges, shows a far-sighted conception of the ultimate growth and interrelation of exchanges that wins heartiest admiration.

Mr. Hubbard made many visits to various cities and endeavored to interest capital in the new invention, and he loaned telephones to men of influence in the hope that daily use would lead them to perceive the future value of the invention. But scarcely one of the men, who should have foreseen the growth of the telephone industry and who might have assisted in establishing it under favorable conditions, gave him any encouragement. So he was compelled to turn to men who had little money, but much energy combined with a strong faith in their own abilities to succeed. Thus, as a rule, it was men of this type, rather than the financier, who helped to lay the foundations of exchange telephone service in many localities.

In the beginning the parent company had seriously considered the advisability of forming a second organization to build, equip and operate telephone exchanges in all our cities. Though this plan was strongly advocated by men whose faith in the greatness of Alexander Graham Bell's invention and in the ultimate success of the telephone had never faltered, four good and sufficient reasons soon showed how impracticable it would be to carry the plan through on a satisfactory basis:

First. The more the plan was analyzed the greater appeared the actual cash investment that would be required to establish exchanges in all the cities in the United States, until the total amount that would be required aggregated more than a hundred millions, a sum almost fabulous in 1877, yet actually necessary if this new and untried industry was to be properly built up.

Second. For one company to undertake to build exchanges in all

the cities in the United States, and interconnect the same with toll lines, would necessarily involve much delay in building, and compel many communities to wait several years before receiving telephone service.

Third. The absence on the part of capitalists of faith in the intrinsic value of this incomparable invention precluded the possibility of financing any large telephone exchange system embracing the principal cities in one state only, to say nothing of a proposition of such magnitude as to include the leading cities throughout the country.

Fourth. Local interest supported by local investments was absolutely essential to insure even the small growth that was then considered satisfactory.

How great this lack of faith was, and how often Alexander Graham Bell, Gardiner Greene Hubbard and Thomas Sanders and their early associates met with rebuffs when inviting capital to join with them in promoting the establishment of telephone exchanges in 1877, and how widely capitalists were misled into believing that the telephone had 'no commercial value,' by the very men who should have been the first to grasp the possibilities in so revolutionizing an invention, may be shown in two quotations.

In November, 1876, after Sir William Thomson's glowing description of the successful telephone experiments at the Centennial had aroused the interest of scientists everywhere, a prominent electrician, who later claimed to have invented the telephone, wrote to his attorney on November 1, 1877:

> As to Bell's talking telegraph, it only creates interest in scientific circles, and as a scientific toy it is beautiful, but of no commercial value. We can already do more with a wire in a given time than by talking, so its commercial value will be limited.

And the editor of *Engineering*, of London, then the leading engineering publication of the world, in calling attention to 'the extreme simplicity of receiver and transmitter,' stated in the issue of December 12, 1876, that the instruments were

> so simple indeed that were it not for the high authority of Sir William Thomson, one might be pardoned at entertaining some doubts of their capability of producing such marvelous results.

Only those familiar with the situation can realize how great and how unreasoning was this lack of faith on the part, not only of capital, but of scientists, mechanicians, merchants. But here is an excerpt from an editorial written at the close of 1883, by a journalist thoroughly conversant with the telephone situation from the beginning:

> The issuance of Bell's patent, on March 7, 1876, attracted little or no attention in the telegraphic world. The inventor was practically unknown in electrical circles, and his invention was looked upon, if indeed any notice at all was taken of it, as utterly valueless. In fact, we believe that not a single person could have been found, however well versed in telegraphy or electricity, who would have given a hundred dollars for the patent within three months after its issue.

. . . We very much doubt if it could now be purchased for $25,000,000. It is probably by far the most valuable single patent which has ever been issued.

During the winter of 1876 and the spring of 1877, there appeared in the daily papers a number of references to Graham Bell's statements concerning the general use of the telephone, the central telephone exchange system, aerial and underground cables, the long-distance service, etc. Lack of space prevents the citation of all, but the general tenor of his remarks are shown in the following excerpts.

The Boston *Sunday Herald,* of October 22, 1876, declared that

the future possibilities of the telephone can scarcely be overestimated. The economic and other advantages thus opened to the contemplation of the thoughtful are too self-evident to be descanted upon.

On February 13, 1877, the Boston *Globe* in reporting Graham Bell's lecture before the Essex Institute, at Salem, said:

We have the pleasure of presenting to our readers this morning, the first despatch ever sent to a newspaper by the newly invented telephone. . . . Professor Bell closed his lecture by briefly stating the practical uses to which he was confident the telephone could be applied.

On Wednesday evening, April 25, 1877, Graham Bell delivered a lecture in Huntington Hall, Lowell, and the next day's *Lowell Citizen* contained a report of the lecture reading in part as follows:

At about half-past nine o'clock Prof. Bell spoke of the possibilities of the future regarding the telephone. He predicted that private houses would be connected with stores and offices and shops, and orders for the day's dinner as well as important business of every kind could be transmitted without leaving the room. In the future merchants would be enabled to order goods from New York, Boston or other cities by word of mouth, instead of telegraphing or taking a long journey.

That the editor of the *Citizen* was impressed with Alexander Graham Bell's enthusiastic presentation of his subject, and realized that this uplifting faith in the future of his invention must be based on an accurate knowledge of what it might accomplish once its function was fully comprehended, is evident in the leading editorial. And this editorial is remarkable in that it is the first of all editorial references to 'a central telephone office,' and the first of all favorable comments on the probable success of exchange telephone service. In part the editorial reads:

Professor Bell believes that in the near future a central telephone office will be established in all our cities, with which the police, the fire department, most business houses and many private residences will have connections. When this is done any person having the connection can call the police, report a fire, order a dinner or chat with a neighbor without leaving the room.

Graham Bell also lectured in New Haven on April 27, in Manchester on May 8, in Springfield on May 12, and then he went to New York and delivered three lectures in Chickering Hall. The third lecture was delivered on Saturday evening, May 19, 1877. Therein he referred to the convenience that long-distance service between Boston and New York would be to the business man, touched upon the use of

the telephone booth not then devised, and upon the value of the central exchange as a public convenience, stating as one illustration:

It is a rainy morning, and Mrs. Smith does not want to get wet. She calls on the central office to connect her with Mr. Jones, the butcher. It is done. So with offices and houses, or workshops, and many other places.

Reports of other lectures could be cited, but a sufficient number have been shown to illustrate how clear was Graham Bell's conception of the usefulness and economical advantages of telephone exchange systems and long-distance telephone service before either one existed. And by reason of his cheery optimism and his logical, convincing arguments that the establishment of telephone exchanges in every city would necessarily follow, and that telephone service would become an indispensable feature in business and social life, his associates gained greater courage to push the exploitation of the telephone.

After considering the several plans presented for the future conduct and expansion of the new business, it was decided to adopt the plan of interesting local capital and cooperation in the establishing of local exchanges and to issue to these local organizations short-term licenses covering a period of only five or ten years. With this end in view agents were appointed to solicit customers in given territory on a commission basis ranging from 25 to 50 per cent.

Where the intention was to construct and operate a local plant the exclusive right to operate under all Bell patents was granted with the proviso that the parent company, if it so desired, could purchase the property of the local company at cost, or at an appraised valuation at the expiration of the license. Then it was arranged that the telephones should never be sold during the life of the patent, but leased, the technical title of ownership being reserved to avoid legal complications, and also to secure territorial rights in the event of default of payment of the agreed royalties by the local companies. Thus the parent Bell company never granted to any operating company any right or interest in its patents nor the right to manufacture or sell telephones.

Within a year this method of locally introducing the telephone met with a cordial reception on the part of many with a speculative bent of mind, if not by permanent investors, and thereafter it became a comparatively easy task to interest local capital in local exchanges having a license covering a period of only five or possibly ten years. The royalty required of the local licensee, amounting to $7 a year for each instrument, was not in the beginning considered exorbitant by local owners familiar with the heavy yet legitimate payments necessary in protecting the licensees from infringing competition, for necessary subsidiary patents, as well as for experiments, the patent risk, and the endless litigation. And when the hard times of 1884 came, and again in 1885, the parent company made many concessions and introduced a sliding scale of rentals that materially lessened these royalty payments.

Even from the first it was perceived that a long-term license would not be equitable to both parties, owing to the new conditions that were arising and would necessarily continue to arise from month to month. With growth and development would come a broadening experience of great value to both operating and parent company, and a lessening of timidity on the part of capital. It was this fear on the part of investors that rendered necessary the issuance of separate licenses for neighboring cities or adjoining territory, or for towns widely separated. Yet it was obvious that the near future was certain to bring changed conditions that would strongly emphasize the necessity for merging several exchanges or even all lines and exchanges within a state under one management and governed by one policy.

Thus it came about that during the four years, 1878–81, local telephone exchanges were established in many towns by individuals or small companies, on the understanding that the local owners were to furnish all the capital required to properly start and develop the industry, while, in return, the parent company would supply the telephones as fast as required, and would protect and defend the exclusive rights to operate under the Bell patents.

Early in 1877, Mr. Frederic A. Gower was appointed 'general agent for the Bell telephone' for all of New England. He assisted Graham Bell in a number of lectures, delivered a number of lectures, and visited nearly all the larger cities in his territory in the effort to secure local capital and cooperation in establishing telephone exchanges. Then he tendered his resignation to take effect on January 1, 1878, in order that he might spend much time in introducing the telephone in European cities. Thus, to take up and systematically continue the work that Mr. Gower had been so actively engaged in, a second organization was formed that may properly be referred to as a subparent company, as it enjoyed equal rights with the first company within a limited territory.

This second company was incorporated on February 12, 1878, under the general laws of the Commonwealth of Massachusetts, with an authorized capitalization of $200,000, all of which was issued in return for $50,000 in cash and for certain patent rights and other privileges valued at $150,000. Exclusive rights 'to use, license others to use, and to manufacture telephones in the New England States,' were granted to it, and during its brief existence it endeavored to thoroughly develop its allotted territory. It secured the right to erect poles and wires in a number of cities and aided in the organization of a number of local telephone companies. Though named the New England Telephone Company it was never in any way related to the later and now well-known New England Telephone & Telegraph Company of Boston.

The stockholders in the New England Telephone Company were practically the same persons who composed the membership of the original parent company, the Bell Telephone Association. The officials were: President, Gardiner Greene Hubbard; treasurer, Thomas Sanders; general agent, George L. Bradley; clerk, Thomas B. Bailey. Incidentally it is worthy of note that since its organization Mr. Bailey has been the purchasing agent of the American Bell Telephone Company. On July 27, 1878, Mr. Hubbard resigned the presidency and Mr. Sanders was elected in Mr. Hubbard's place, while Mr. Bradley succeeded Mr. Sanders as treasurer. Until February 15, 1879, the New England Company occupied room 43 in the Sears building in Boston, when it moved to room 52 Mutual Life Insurance building.

Meanwhile Mr. Hubbard found it difficult to borrow the funds necessary to carry on operations outside of New England. Friendly bankers had loaned generous amounts, but when further advancements became imperatively necessary, they asked for a more tangible form of collateral than certificates issued by an unincorporated association, and it was suggested that the stock certificates of a conservatively incorporated and wisely managed company might be acceptable as security, if offered at a low valuation. So, on July 30, 1878, the second of the parent companies was incorporated under the laws of Massachusetts to transact a general telephone business in all of the United States outside of the New England States. It was capitalized at $450,000, and that amount of stock was issued in return for a cash payment of $50,000 and all the rights and privileges held by its predecessor, the Bell Telephone Association. Its officials were: Trustee, Gardiner Greene Hubbard; treasurer, Thomas Sanders; electrician, Graham Bell, and superintendent, Thomas A. Watson. At first its headquarters were at the Williams factory, 109 Court Street, Boston, but in August, shortly after its organization, it moved to New York City and occupied rooms at 66 and 68 Reade Street. It bore the name: Bell Telephone Company.

The interest awakened in the development of the telephone industry through the activity of these three organizations and their agents created a volume of business, the character of which necessitated the formation of a broader organization, and resulted in the birth of the third parent company, the National Bell Telephone Company, as detailed in Chapter V. The company was organized on March 10, and its charter issued on March 13, 1879. It was formed through the amalgamation of the New England and the Bell Telephone Companies, and succeeded to all the property and patent rights and privileges of both these companies. The new company was capitalized at $850,000, and this amount of stock was issued in return for telephone exchange and manufacturing property representing a cash investment

of $306,900, for $6,500 cash in treasury, and for all the stock of the Bell Telephone Company, $450,000, and of the New England Company, $200,000, valued at $536,600. Within five months after its organization, the headquarters of the National Company was moved from Reade Street, New York, to 95 Milk Street, Boston.

Under the wise and liberal guidance of President William H. Forbes, the practical progressive policy of the National developed a volume of business so large and of so varied a character as to make clear the need of a still broader parent organization able ultimately to assist in carrying the financial burdens of any or all of its operating companies, and to extend substantial encouragement for extended development. Then the successful outcome of the bitter contest with its competitive opponent, the Western Union Telegraph interests with a total of seven thousand established telegraph offices, had drawn to the National company the thoughtful interest of capital seeking productive fields for investment, and soon investors began to overrun the telephone field.

Thus, after a very strenuous life of fifteen months, the National was absorbed by the fourth of the parent companies, the American Bell Telephone Company. This fourth organization was granted a special charter by the commonwealth of Massachusetts, on March 19, 1880, which was slightly amended as of May 21, 1883, in so far as it relates to the holding of stock in the operating companies. The American company desired to have an authorized capitalization of $15,000,000, but the legislature limited the amount to $10,000,000.

At a special meeting of the stockholders of the National Bell Telephone Company, held on Monday evening, March 29, 1880, it was voted unanimously to sell all the property of the company to the American and to transfer the same as of May 1, in return for payment in the form of six shares of the capital stock of the American Bell for each share of the National. This was a reasonable price to pay, as shares of the National had sold as high as $960, according to a statement in the Boston *Herald,* though the par value was only $100, while the last sale of 500 shares had brought $600 a share in December, 1879.

Two days later the National stockholders received a printed notification reading in part:

The American Bell Telephone Company has been organized with a capital of $7,350,000, divided into 73,500 shares of $100 each. This new company has voted to purchase all the property and assets of the National Bell Telephone Company for the sum of $6,500,000, payable in stock at par (65,000 shares) and to offer tne remaining 8,500 ($850,000) at par to the stockholders of the National Bell Telephone Company as of date of April 1, 1880.

Of the 65,000 shares transferred to the National Company in return for all its property, patents, etc., 51,000 shares, or $5,100,000 were distributed among the national stockholders according to their respective

holdings; 1,145 shares were used to take up the convertible notes issued; 1,500 shares were sold by the trustees in open market for $332,935.75, and 1,050 shares were held by the trustees to use in liquidating future claims.

The new company occupied offices at 95 Milk Street, Boston, and at the first meeting the following officers and directors were elected:

W. H. Forbes, President.
T. N. Vail, General Manager.
W. R. Driver, Treasurer.
O. E. Madden, Superintendent of Agencies.
T. A. Watson, General Inspector.
A. Graham Bell, Francis Blake, Consulting Electricians.
J. P. Davis, Engineer.

DIRECTORS

William H. Forbes.	Francis Blake, Jr.	Alexander Cochrane.
Charles S. Bradley.	Richard S. Fay.	George L. Bradley.
Gardiner Greene Hubbard.	William G. Saltonstall.	C. P. Bowditch.
Thomas Sanders.	Charles Eustis Hubbard.	

The successful launching of the American Bell Telephone Company, notwithstanding that the three earlier companies had never paid a dividend, was a splendid tribute to the intelligent persistence displayed by the pioneer advocates in promoting so serviceable a public utility, as well as to their executive and financial ability. And the magnitude of the task of merging all these interests into one comprehensive organization may be more clearly realized in the brief statement that in its consummation there were involved about five million dollars in cash, and a million in property and patents. In 1880, six millions was a sum relatively many times greater to financiers, when million-dollar corporations were more scarce, than at the present time, when a hundred millions may be a fair and a necessary capitalization.

In his annual report for the first fiscal year, ending February 28, 1881, President Forbes of the parent company said:

After two years passed in a struggle for existence, and a third largely devoted to the settlement of disputes inherited from that contest, the owners of the telephone patents, at the beginning of their fourth year, for the first time find themselves free from all serious complications, with nothing to prevent the company from directing its whole working force to the development of the business, and with a well-defined policy for its future operations, which seems to be working well in all parts of the country. . . .

A large amount of work has been done in the electrical and experimental department, both in examining new inventions and testing telephones and apparatus, and in studying the question of overhead and underground cables, and the improvement of telephones and lines, for both short and long-distance service. This work is expensive, but it is of the first importance to our company, and must be continued.

Much of the electrical and legal work of these first years of the company, and, indeed, some of our expenses incurred in studying and classifying the business, are substantially for the establishment of the property, and might be charged to construction and capitalized, but the directors have preferred the more conservative policy of charging everything to operating which could reasonably be put there, although the result upon the books appears less favorable, in consequence, than the business prospects might warrant us in exhibiting.

THE BALSAM PEAKS—THE HEART OF THE SOUTHERN APPALACHIANS

By SPENCER TROTTER
SWARTHMORE COLLEGE

An Appreciation

FROM a field near the upper end of the town you could see three mountain peaks, two near together and one farther to the west, that stood out sharply against the cool, yellow evening sky, less defined when bathed in the shimmering bluish haze of diffuse sunlight or when brushed by the trailing vapors of passing clouds, but at all times fascinating in their lofty isolation and in the invitation which they held to adventure and to explore. These were the Plott Balsams. Away to the southeast, beyond Deep Gap on the farther side of Lickstone, we knew of a trail that followed the crest-line of the Divide, higher and higher until it reached the summit of the Richland Balsam, second only to Mount Mitchell in the galaxy of the Southern Appalachian peaks. Down the main street of the town one's eye went beyond the narrowing vista of houses, miles away to the blue uplift of Crabtree Bald. To whatever point of the compass you might look there were mountains, but the Balsams held the loadstone that drew us to their summits. Some persons there were who declared that they could detect a trace of balsamic fragrance when the wind was westerly, wafted from the high peaks six miles away. I, for one, could never reach this exalted state of sense or of imagination, whichever it might be. No man, however, is a competent judge of the condition of another's sensorium. It is enough if he follow his own nose and its teachings.

One Sunday in mid-June we essayed the Enos Plott Balsam by the trail that a horse could follow to the summit. As we turned the corner of a street, where the town fell away into the valley of the Richland, a Carolina wren was proclaiming the joy of life in no uncertain voice. This I remember, and also that the air was crystal clear and flooded with sunlight. Our way led for some miles along a road that followed the stream through the farming land of the valley, past an occasional house and barn and the patch of tobacco that was grown for home consumption. A 'neighborhood' road branched off from the main-traveled highway, and this we followed until it ended in the woods at a fence on the other side of which the trail began. Here we plucked some sprigs of the wild indigo (*Baptisia*), a plant with yellow, pea-like

blossoms, and each of us decorated his horse's head as a sure remedy against the tormenting flies.

I never think of this fence and its old gate through which we passed, with the narrow trail starting abruptly up the steep slope of the wooded mountain side, without vaguely picturing the wicket-gate through which Christian went at the outset of his journey. If ever there was a land of promise surely it must be at the farther end of that toilsome trail with glimpses of the Delectable Mountains here and there on the more open stretches of its upper levels.

For long the beasts scrambled upwards, stopping to breathe where the steepness was broken by some irregularity. We held on bravely to the manes, leaning well forward, and pressed our legs close as we scraped by the trees that beset the trail. It was a long ridge that the trail followed, the land on either side falling away quite sharply. Higher up the woods became more open, with little undergrowth and long vistas among the trees. The bloom-covered bushes of the flaming azalea (*Azalea lutea*) were scattered far and near, glowing spots of color in the sunlit spaces of the woods, and the crisp leaves of the galax (*Galax aphylla*), shining bronze and green, spread in thick patches along the way. The woods on this midway portion of the mountain were for the greater part made up of oak and chestnut. Lower down, near the foot of the mountain and in the deep, moist coves between the ridges, the tree life was more varied and the primeval forest more luxuriant and jungle-like in character. There the buckeye (*Æsculus*) and the tulip tree (*Liriodendron*)—the yellow poplar of the lumbermen—grew to truly magnificent proportions, and many other Carolinian forms prevailed.

In the dry, open woods on Huckleberry Knob, a wild turkey suddenly started up before us and ran swiftly down the slope. It was a bit of the primitive wilderness life and gave a fine touch to our adventure. Huckleberry Knob is one of the three Balsam peaks that we had so often gazed at from the town; the lower one of the two that appeared close together. It was, in reality, but a hump on the southern shoulder of the main Balsam, the summit of which we now for the first time in our ascent caught a glimpse of through an opening in the woods, towering far away to the right—a stark peak with a bristling mane of fir forest. We were still among the oaks and chestnuts on Huckleberry Knob, some distance below the fir zone, but even at this altitude the air had a cool, autumnal snap and I was glad to have a thick jacket which had been uncomfortably warm in the valley. The hardest part of the climb was over, so White told us, and the horses had a comparatively easy time following the trail, which now led for some distance along the upper edge of a steep slope. The soil was a rich black mold of considerable depth that made a precarious footing, especially on the

steeper parts where a horse would now and then slip badly. Scattered droves of half-wild hogs were rooting in the earth in the woods below us; lean, dark-colored fellows with long legs that bespoke a life of activity.

The oaks and chestnuts became straggling and scrubby; there was more sunlight through the woods, with an occasional glimpse of a distant mountain; sky-lines across gulfs of hazy blue. It was here that we saw the first evergreens—a few scattered trees along the upper edge of the deciduous zone. The tannin-smelling woods of oak and chestnut presently ceased altogether and we passed into a boreal forest, the trail winding through dense clumps of spire-topped firs and spruces, interspersed with open, grassy parks. One could not help breathing deeply in this rarer air, redolent with the aromatic fragrance of balsam that recalled long-forgotten Christmastides. I should not have been surprised if the paint and varnish smell of new toys had greeted me on these Balsam heights. Dainty bluets (*Houstonia*) of the northern spring made bright patches on the green moss, and here and there the *Clintonia borealis* reared its wand of yellowish-green flowers above the broad, glaucous leaves. We had left summer on the lower slopes; it was spring on these mountain tops; we had left Carolina in the valley, with its passion flowers and its wild indigo; it was Canada that we found above the six-thousand-foot line.

There was an impressive stillness about these evergreen solitudes that heightened the feeling of remoteness and isolation. Nor was bird life at all conspicuous, only the occasional chip of a Carolina junco. The tinkle of a bell sounded pleasingly when some mules met us on the trail, one with a bell fastened about its neck. White and Chalfant began talking of the fine pastures on these high slopes, where stock, from farms in the valley, is turned out to range at will. The animals are often more than half-wild in their freedom, and this is especially the case with the young cattle and hogs that are born there and that frequently reach maturity before seeing a man.

The trail presently led us into one of these alpine pastures—a broad, open meadow on the rounded shoulder of the mountain, falling away on either side into the fringe of evergreens. Here the juneberry (*Amelánchier*) was growing, with its red fruit clusters, and the mountain holly (*Ilex monticola*), and here and there a gray bowlder outcropped above the rich grass turf, and here and there a scattering clump of spruce and fir. Some distance off a number of young cattle were grazing, and farther down the slope some sheep and horses watched us with mingled distrust and curiosity. It was like riding along the roof of the world to traverse this sky-land meadow, lifted up like some enchanted country.

From this meadow our way led up the western flank of the peak

through the groves of mountain rose bay—the Catawba rhododendron (*R. Catawbiense*)—that grows only on the highest summits of this mountain land. On the summit of Lickstone Bald we later found it a shrub scarcely three feet in height, but on the Plott Balsams it was arborescent—a tree twenty feet high—and we rode the rest of the way under bowers of lilac and rose bloom. What I had read and heard of the scenery of Himalayan slopes was visibly present—the gorgeous blossoms of rhododendron jungles and the dark forests of fir bathed in the azure light of the upper world. Nowhere on this continent can one find a nearer approach to Himalayan vegetation, and I would fain add scenery—save for the absence of that snowy range that towers above the tree-line zone. The fir tree of these Carolina mountain tops is Fraser's balsam fir (*Abies Fraseri*), a distinct species, though closely allied to the common fir of northern evergreen forests. The same resin blisters are found on the trunk and limbs as in the northern species, and it is the exudation from these that fills the air with balsamic fragrance. The woodsmen of this region call the fir a "she balsam" in contradistinction to the spruces, which are called "he balsams" and on which no resin-filled blisters are found .

Plott Balsam is a more decided peak than any of the surrounding mountain summits. It falls away steeply on all sides from a level space on the top scarcely larger than the flat roof of some tall building. This gives one the impression of great upliftedness—of standing on the pinnacle of an exceeding high mountain and beholding the kingdoms of the world. The timber had been felled on the very summit, presumably to give a lookout, and we had a superb view of the valley of the Richland more than three thousand feet below. In every direction mountain masses lay before us—range beyond range—like a vast relief map. To the north, on the farthest verge of the horizon, loomed indistinctly the range of the Great Smoky. Toward the east and south the eye swept from Pisgah along a quadrant bounded by the hazy uplift of the Blue Ridge more than thirty miles away. It was not this vista of mountains, however, that impressed me most. It was the vastness of the sky with its cloud pageant. Here was the birthplace of the cumuli. Wisps of vapor, formed in the uprising currents on some high mountain top, streamed off in the wind like a banner, grew and grew, rolled into a fleecy mass, waxing greater, until the stately pile of the cumulus floated on with its fellows—a Phæacian fleet that would vanish in the sunset on some distant horizon.

The cumuli breed the thunderstorms that gather over these mountains in the early afternoons of summer. During the latter part of June and through July "thunder heads" would be hovering over the western ridges, casting their deep shadows on the slopes and the valley. Downpours of rain were frequent and one soon got accustomed

to a drenching. There is a certain feeling in being overtaken by these mountain rain-storms that lifts one above the mere petty annoyance of wetness. It savors of primitive things and is probably a reversion to remote ancestral ways of life. On one occasion Lucasta and I, with two piebald mares and a "hound dog," made the ascent of the Plott Balsam. It was a lowering morning and did not promise much in the way of views, but a wedding anniversary was to be kept in cloud-land—as near as possible to the place where such blissful states are said to have their origin. Beyond Huckleberry Knob we found ourselves in a driving mist and heard the rumble of thunder in the ravines on either side. We missed the trail above the alpine pasture and, tying the horses in the firs, blazed our way up the peak. The air was clear of mist on the summit; the cloud was beneath us and we looked out on its gray vapors as one might look upon the sea from an island shore. A rift suddenly disclosed a bit of the valley—a fleeting glimpse, for the dull mass as quickly rolled together again. We congratulated ourselves on the day. You may behold the expanse of land and sky many times from these outlooks, but rarely does it chance that one sees the earth through a cloud rift. The peak of Plott Balsam was above the cloud; when we returned to the horses it was to find them still in the same bewildering mist. We shared some biscuits with the companionable hound, the horses munching their measure of grain, and all the while the cloud drenched us and the dripping firs distilled a fragrance that entered into the soul. There was a fine sense of being a part of the primitive life of things—of the mountain, and the weather, and the vegetation—enough of the aboriginal man and woman in us to find joy in such surroundings.

The rain that had swept the slopes below the alpine meadow had made the trail so slippery that walking was preferable to riding, especially where the horses had to slide down the steeper parts. There had been a heavy thunder-storm in the valley and all the while we were in the cloud itself and above it, seeing no lightning at all from our elevation.

Lickstone Bald is a very different summit from the Plott Balsam. It begins as a long upward-trending ridge from Deep Gap, through dry open woods until it reaches a deciduous timber-line above which it is treeless—no evergreens and no arborescent rhododendrons. One gets the impression of riding along the ridge pole of an immensely high-roof, so narrow is the crest-line and so steep the side slopes. The trail ends abruptly on the brow of a sharp declivity that falls away to the lower slopes for several thousand feet. These lower slopes about Lickstone are covered with a magnificent forest of oak, chestnut, magnolia (*Magnolia Fraseri* and *M. acuminata*), tulip or yellow poplar, buckeye, sourwood, and many other varieties. The showy flower-clusters of the

sourwood (*Oxydendrum*) are visited by great numbers of wild bees and sourwood honey has a reputation that is not confined to the locality. I have some pleasing memories of mountain breakfasts sweetened with this dainty product of the wildwood. Eating wild honey, like drinking goldenrod tea, or devouring handfuls of wild berries, or partaking of any natural harvest, gives a fine edge to the business of eating, at least to the imaginative side of it.

On the trail between Deep Gap and the Allen Branch, and not far from the mica mines on the western side of Lickstone, stood the cabin of Arnold Guyot's old guide, Wid Medford. Guyot spent much time in these parts, surveying and studying the various mountain groups. A peak of the Great Smoky Mountain bears his name, and the United States Geological Survey has memorialized the work of this pioneer in geographical science by naming one of its topographical sheets "Mount Guyot." We took refuge one afternoon under Medford's porch during a thunder shower and the old man talked about Guyot, chuckling with great glee over the wrath and discomfiture of the near-sighted professor when on a certain occasion he had blundered into a yellow-jacket's nest. From the old fellow's yarn I gathered that he had purposely led the unsuspecting geographer into the trap, by way of a joke; and the memory of it was still very green. If only I had heard this story of Medford's when as a boy I struggled with a Guyot's School Geography, how I should have envied the guide and the yellow-jackets.

Southward from Deep Gap a trail leads up to the crest of the Divide—the water-parting of streams that flow west into the Tuckasegee Branch of the Little Tennessee, and east into the west fork of Pigeon River. The trail follows along the summit for many miles, through a dense forest of balsam fir and close to the precipitous eastern side, from which one has an overlook of the Pigeon Valley three thousand feet below. A spongy carpet of bog moss (*sphagnum*) gives a truly Canadian touch to the fir forest of the Divide. To look down from these boreal heights on a valley where sorghum is growing, where cardinals are whistling, and passion flowers are blooming, lends another point of view to one's ideas of geography. The trail goes steeply up from Deep Gap to the top of Cold Spring Mountain, where Magee and I ate our lunch, smoked a pipe of tobacco, and drank crystal water from the spring. Beyond Double Spring Gap the crest-line of the Divide gradually rises to the summit of the Richland Balsam, six thousand, five hundred and forty feet above the sea-level. There is a glorious view of peaks and ridges from this Balsam top, with the great dome of Mount Mitchell (6,711 feet) rising above the Black Mountain group, but I did not get the same sense of upliftedness as I did on either of its lesser neighbors—the Plott Balsam and Lickstone Bald.

This I think is because so many high ridges are in the immediate vicinity and there is no near view of a valley.

Between Double Spring Gap and the Richland we fell in with a "moonshine" scout, armed with a long-barreled gun, who told us he had been watching for a bear. Our presence had evidently been heralded by some one sent ahead from a cabin on the side of Lickstone where we had stopped early in the forenoon to inquire the way. The man was quite affable when he found out who Magee was and that we were on a harmless tramp, looking for plants and mountains. He went with us to the summit of the Richland, pointed out many interesting landmarks, and offered to take us to his home to spend the night. I gave him a "poke" of fine-cut tobacco, which he said was too soft for him, but that his little boy would be glad to have it. Thus I unwittingly encouraged a vicious habit in one of tender years. Every one uses tobacco in these mountains, the women taking it in the form known as "dipping"—a stick, one end of which is moistened and dipped in snuff, held between the gums and cheek. On our way back we met another man carrying a heavy sack on his shoulder; undoubtedly corn destined for some secluded spot where the alchemy of a crude still would transmute it into golden "moonshine."

An almost obliterated trail leads from the Richland Balsam, by a fir-crowned ridge to Caney Fork Bald, the treeless top of which is a grazing range. We saw it first against the glow of a western sky, the pasture slopes of its dome-like crown bathed in cool shadows. Scattered groups of cattle, sheep and horses gave a truly pastoral touch to the scene. There is something fascinating in these remote mountain pastures with their vast reach of sky, and girt about as they are by a world of forest-clad ridges. They are the park-lands of the Southern Appalachians.

The Balsam peaks, with their glorious alpine meadows, their boreal forests and rhododendrons, and the sylvan wealth of their lower slopes, lie in the very heart of the region which the government of the United States now has under consideration to purchase and set aside as a national forest reserve. Apart from the wisdom of thus preserving a vast tract of forest land and conserving the water-supply of many important rivers, there is, in this idea of an Appalachian National Park, an appeal to the æsthetic side as well—to that love of wild, undisturbed nature and of mountain scenery that seems to be a natural instinct in large numbers of our people. John Muir has sounded this note in his delightful book on the national parks of our western country. The Southern Appalachians have likewise a charm of their own. To wander over these mountain meadows and balsam-covered peaks is to enrich one's life and store the mind with fragrant memories.

THE RE-AWAKENING OF THE PHYSICAL CONSCIENCE

By RICHARD COLE NEWTON, M.D.

IN the recollection of men not yet old, such a thing as physical education was scarcely thought of in America. About fifty years ago Dr. Oliver Wendell Holmes wrote: "I am satisfied that such a set of black-coated, stiff-jointed, soft-muscled, paste-complexioned youth as we can boast in our Atlantic cities, never before sprang from loins of Anglo-Saxon lineage. . . . Anything is better than this white-blooded degeneration to which we all tend."

This condition of things had not, however, been reached without some concerted efforts to prevent it. In 1826 Harvard had started the first American college gymnasium in one of its dining-halls, and later in the same season, a number of gymnastic machines were put up on the playground known as the Delta. Gymnastic grounds were established at Yale the same year, and at Williams, Amherst and Brown in the year following. Competent instructors, however, were not to be had and no one knew how to produce them, so the movement was abandoned in five years time.

About thirty years afterward under the management of Professor Hitchcock, compulsory gymnastics were instituted at Amherst with very happy results. Within twenty years about fifty other institutions of learning had followed Amherst's lead; and now at Yale, Columbia, Princeton, Oberlin, the University of Pennsylvania and the University of Wisconsin gymnastic exercises are compulsory for all students for at least a part of the college course. The excellent results of the prescribed drills and exercises at Annapolis and West Point have, no doubt, contributed to the growing conviction that proper bodily development should be a part of every educational system. The students in many schools, as we shall see later, have taken their own physical education in hand. The present passion for athletic sports seems well-nigh universal and has gained such headway that it is evident that it must be taken very seriously. Over $1,000,000 are annually spent on college athletics in the United States, an increase of five-fold in the past ten or twelve years, and some young men, at least, unquestionably go to college for the specific purpose of playing upon the university teams. The stroke oar of the university crew, is by many, perhaps a majority, of his classmates held in higher honor than the valedictorian. Even as some of the youth of Hellas preferred the laurel crown, won in

the Olympian games, to the prizes offered for the greatest achievements in poetry or art.

Eighty years ago there was not a college gymnasium in the United States, to-day a college without a gymnasium is unknown. Eighty years ago gymnastic instructors were not to be had and no one in America knew how to produce them. Now there are a number of normal and training schools turning out physical instructors and yet the demand keeps so far ahead of the supply that such teachers are paid, when engaged, about twice as much as the teachers in other branches, and, as for the colleges, gentlemen of liberal culture, graduates in the arts and in medicine, are glad to accept positions as directors of the gymnasia and of the physical training.

In two hundred cities of the United States there were three years ago vacation schools, and schools of like character were projected in Buenos Ayres and Amsterdam. Similar schools are also in operation in London. These schools are chiefly for the teaching of manual training, games and deportment, and employed in New York City 1,400 teachers in 1903. In St. Louis a practise was instituted of taking the older boys in the vacation schools to see the principal base-ball games played in the city, as a means of enhancing their interest in manly sport.

As the result of a *questionnaire,* Dr. McCurdy, of the Springfield Training School, found that out of 555 cities in the United States, from which he got replies, 128, or 23 per cent., employ special physical training teachers (102 men and 189 women). Practically all the schools in the 555 cities had playgrounds. Of 427 schools not employing special physical training teachers, 190 used some special system of physical training. Of the high schools of the 128 cities employing physical training teachers, 113, or 88 per cent., have football teams, and in 386 other cities, 319, or 83 per cent., have football teams, while half as many of the grammar schools in both classes had football teams. In 36 per cent. of the cities where special physical training teachers are not employed, and in 68 per cent. of those where such teachers are employed, there are in addition special athletic instructors, or "coaches," for the most part under the direction of the students themselves. It is a commentary on the courage of American boys that there were more football teams than baseball, basket-ball or track teams in these 514 cities. The large majority of the school superintendents approves of competitive athletics in the high schools. Dr. McCurdy speaking of the need of gymnastic exercises for the girls says, "adequate and satisfactory teaching will be absolutely necessary for both sexes in the near future."

Dr. Luther Halsey Gulick, director of physical training in the New

York City public schools, has just submitted a statement in regard to the athletic clubs formed among the male scholars in the schools. These clubs are maintained by the boys themselves with the aid of the teachers and some outside friends. President Roosevelt is honorary vice-president of their athletic league and other distinguished men are serving as its officers. Especial stress is laid in the statement upon the devotion of the teachers, of whom 411 did volunteer service during the past year in helping the boys with their athletics after school hours. Had they been paid for this work at the same rate which they are paid for their regular duties, they would have received in the aggregate $120,000, a very handsome contribution to the cause of school athletics; especially when it is remembered that many teachers require the hours after school for post-graduate and other work necessary for their own professional advancement.

Two hundred and twenty-four schools in Greater New York reported on athletics last year, of which 83 had regular organizations and 165 had available grounds for practise. The students pay dues into the athletic treasury at an average rate of twenty-eight cents per term, and 21,873 of them took part in the athletic sports during the year. Dr. Gulick has under him a supervisor of physical instruction in each borough and a total of fifty or sixty teachers in this branch of public instruction. The work has been admirably organized. Similar organizations have been started and have made excellent progress in Philadelphia, Boston, Chicago, and other cities. Emissaries from various foreign governments have visited the physical training schools of New York to study their methods. Two or three delegations have been here from Japan.[1] The director of physical training in the schools of the City of Mexico has recently visited New York on his tour around the world to inspect the various systems of physical instruction now in use, and upon his recommendation three men and three women will be sent to New York to receive the technical training requisite to fit them to teach physical education in the City of Mexico. One such teacher (a woman) has already gone from New York to work in the City of Mexico.

The United States government is now sending the director of physical training at West Point to visit England, Germany, France, Italy, Austria and Sweden for the purpose of thoroughly studying the systems

[1] The great interest which Japan has always taken in matters of physical education showed itself in 1876 by the visit which her vice-minister of education paid to Amherst College under orders from his government to study and report upon the system of physical instruction in use there. This was followed by a request from the Japanese government that an instructor be sent from Amherst to introduce Dr. Hitchcock's system into the government schools in Japan. The request was complied with to the great satisfaction of the Japanese.

of physical training practised in the armies of those countries. The Greek government has recently requested the authorities of Harvard University to send information regarding American gymnasia that will aid in constructing and equipping the gymnasium at Athens.

The Sunday Schools have also begun organizing athletic leagues. In 1904, twenty-five Sunday Schools in the borough of Brooklyn organized an athletic league which had a membership of fifty schools in a few months. Notices now appear in the daily papers of athletic meetings, including wrestling and similar sports, by church societies. While this might be regarded in the light of an effort to fight the devil with his own weapons by providing some sports that will really attract men and boys to the church society meetings, nevertheless it is due in part at least, to the widespread demand for physical education; a phase of modern life long since utilized by the Young Men's Christian Associations. Of late years, however, the increased demand for this kind of teaching has taxed the resources of the associations heavily, and the work is constantly growing, as the following figures will show: The attendance at the Young Men's Christian Association gymnasia in this country has increased from about 50,000 ten years ago to 154,000 in 1906, or over three-fold. All the extension work, so called, which is the teaching of physical exercises in schools, colleges, churches, clubs, etc., by Christian Association men, has been developed in the past decade, whereas, "the shop work," namely, teaching the industrial classes right habits of living, has been taken up within the past three years, and 271 leaders are engaged in work of this kind.

Ten years ago, eight per cent. of the Young Men's Christian Association directors had received technical preparation as physical instructors. To-day, thirty-nine per cent. have received such preparation. So in the Young Women's Christian Association physical instruction has become an important feature. There are at present over 80 associations, out of 138 reporting, giving such instruction, whereas sixteen years ago there were only two. Of a total membership of 68,803 women, there were in 1905 11,153, or 16 per cent., enrolled in the physical training classes, as against 9,001, or 13 per cent., enrolled in the Bible study classes.

That other countries feel the working of the same leaven, the following incident testifies: Not very long ago, the Pope consented to act as patron of the athletic societies of Italy, and invited them to give exhibitions in the courts of the Vatican. This innovation met with great opposition from the members of the papal court. His Holiness, however, was not to be dissuaded from his purpose, saying to the protesting cardinals, "Come and see these brave boys, you will be rejuvenated by fifty years, and they will gain from it in the health of their bodies, and above all in that of their souls." Accordingly, races, trials of strength and gymnastic contests were held in the great courts and

gardens of the papal palace, the contestants receiving over two hundred gold and silver medals from the Pope, who had caused temporary thrones to be erected for himself and his court from which they witnessed the sports. Even in the island of Porto Rico athletic contests are superseding cock-fighting as a national amusement.

Not only, however, is there an unwonted activity in physical education, but the subject of personal and general hygiene never before received one half the attention that it does at this moment. The city of Philadelphia alone spends more resources and employs more agents in the interests of public health to-day than did the whole English-speaking world a century ago. Not only has the movement to give every child, rich and poor alike, a good physical education become quite general, but steps are also taken to guard his health from contagion and from every injurious influence during his school life.

The first international congress on school hygiene was held in Nuremberg in 1904 and has been followed "by increased literary activity in nearly every country." The second is called to meet in London in August, 1907. King Edward will be the patron of the congress, and Sir Lauder Brunton its president. Steps are being taken to interest the entire civilized world in the effort "to promote by continued activity, in any way the cause of health and knowledge in education." Medical inspection of schools was introduced in Boston in 1890; in Philadelphia in 1892; in Chicago in 1896; and in New York in 1897. In Brussels special school physicians were first appointed in 1874. Now dentists and oculists have been appointed to the schools, and instruction in hygiene is given in eighty-five per cent. of them. Similar measures have been inaugurated in nearly every capital of Europe, and in the high school of Brookline, Massachusetts. The Russian Society for the Preservation of the Public Health has recently arranged a program for the investigation of the hygienic condition of the schools, and probably in every city of any size in America and many country places as well, medical inspection of schools is now a regular practise.

The great educational value of play, as such, has at last begun to be recognized. A German commission some few years ago visited the English public schools under instructions to study the influence of the games and sports carried on there upon the physical and intellectual development of the students. Their report was such that steps were immediately taken to introduce athletic sports and games into the German schools. An annual of four or five hundred pages entirely devoted to play is now published in that country, where, in fact, most of the pedagogic movements of the past century have originated, and after careful investigation, the play ground movement was systematically undertaken there; and there is now in some German cities a law requiring that each school shall provide a minimum play space for each

pupil, which in Munich, for example, must be at least twenty-five square feet in area. In Berlin, there is a forty-acre play ground intended solely for small children. Play conferences are being held annually in the larger German cities and thousands of teachers are being taught to play games with the children.

France, on the other hand, has manifested much less interest in play. The games played by the children are mostly of a trivial nature, and there seems to be no literature on the subject. The superior morale of the German army, as evinced in the Franco-Prussian War, was the natural consequence of the better educational methods of the Germans. As the Duke of Wellington asserted that the battle of Waterloo was won on the football fields of Eton and Rugby, so one might say that the patriotic ardor of Jahn, who taught the Prussian soldiery gymnastic exercises from patriotic motives, bore fruit in the victory of Sedan. Yet in France, a strong attempt was made a few years ago to popularize athletic sports. Prizes were offered by various corporations and municipalities for excellence in various contests, in which thousands of the people, mostly I believe employees of the factories and shops, took a more or less conspicuous part.

In England, the home of manly sport, one finds many municipalities owning their football and cricket fields, just as they own a town hall, and many of the working men and boys spend their half holidays playing games. The public schools in that country are admirably supplied with playgrounds, and cricket and football are compulsory in these schools for all the scholars physically qualified to play, and, furthermore, the teachers are required to play with the pupils; and now in London the authorities declare their intention to have a playground within a quarter of a mile of every home.

In the United States there is an effort being made to replan our cities so as to make adequate provision for play for young and old. Our playgrounds are now absurdly inadequate. Until 1899, a section of New York City, containing 500,000 inhabitants, had no open space whatever for play. The movement toward bettering this condition of things is so vigorous and so general, thanks to the efforts of such philanthropists as Jacob Riis, and the results of what has already been accomplished in New York are so gratifying, that great and continued improvement may be confidently expected. The city now sets aside, we are told in the report of the United States Commissioner of Education, $300,000 each year for the purchase of playgrounds, and $1,000,000 a year for small parks. Unfortunately it will take $100,000,000 to buy enough land to provide the 630,000 children now in the city with room enough to play in.

Chicago has over 73 acres of playgrounds; Philadelphia 110 acres; Brooklyn 40, and Boston, the most intellectual city in the country, has

the largest area of playgrounds, nearly 200 acres. In each of the new playgrounds of New York, which were opened in seven of the smaller parks in 1903, there were gymnastic and kindergarten instructors in charge. These are for children under fifteen; Chicago has five or six such playgrounds, and ten more were to be opened in 1903. The new municipal playground, in Seward Park in New York, is probably the best in the world. It cost the city $2,500,000. There are from two to three thousand children playing there most of the time when the schools are not in session, and at 7 P. M. from 6,000 to 7,000 are there, practically every day. A philanthropist has offered to spend $4,000,000 in laying out and equipping a playground, bathing pavilion and beach on Staten Island, and providing a steamboat to take a large number, probably a thousand, poor children from New York to the beach and back every day. So long ago as 1902 there were ten roof gardens provided in New York City, at each of which the average daily attendance was 2,000. There were besides twenty play centers and seven recreation piers. Swimming-baths were also provided and fifty swimming teachers. In Glasgow were the first municipal playgrounds, and be it observed in passing, this was one of the first cities in the world to adopt municipal ownership of public utilities.

As playgrounds are gradually being established all over the civilized world, so opportunities for proper personal cleanliness are gradually being provided for the humblest citizen. In Munich a public bath house has just been opened. A gift to the city from a private citizen. It cost $500,000, twice as much as the complete gymnasium at Yale. Public baths have been opened in London and other foreign cities. In Boston, of the American cities, probably the best bathing facilities are provided for the common people. It is estimated that each inhabitant of the city may enjoy five baths a year, whereas in the densely crowded districts of New York, Baltimore and Chicago, the Department of Labor found only two to three per cent. of the houses supplied with baths in 1894. Now, however, in Seward Park in New York, and presumably in the other new parks, excellent public baths are provided in addition to a number of floating baths.

There has been a strange awakening in the Empire of China in these latter days; we can scarcely believe the reports that China is now turning to the light, and that the conservatism of centuries is at last yielding to the influence of modern ideas. But it is so. And one of the best evidences of real advance toward the liberation of man from the moral and physical bondage of generations is that an imperial edict exhorts "parents to refrain from binding their daughters' feet," and declares that men who wish to hold office must not have wives or

daughters whose feet are bound. At Peking a newspaper[2] for women has been established, edited by a Chinese woman; one of its objects is the teaching of hygiene. Another recent imperial edict forbids the smoking of opium in China.

The present world-wide agitation against child labor is another suggestive fact which points toward a physical millenium. Child labor laws have been very generally enacted. In New Zealand all employed women and children have been placed under strict legal protection. The strictest child labor law in the world probably has been enacted in that country.

In the new Japan, physical excellence is part of their religion; it is demanded by Bushido, their moral code, and by patriotism. The feeble of body among the Samurai will not marry. Dr. Griffis informs us in "The Mikado's Empire," that by means of physical reconstruction of the whole people, through improved hygienic and preventive measures against disease and wounds, Japan in 1904 has become a new nation. As compared with their status in 1870, they have been raised to the fifth power. At the same time, the soldiers have increased remarkably in stature, while the recruits in the English army have deteriorated in physique, owing presumably to intemperance and vicious living.

The Turners' societies in America are constantly growing in numbers and influence. Their first normal school of gymnastics was organized in 1861. Over sixty per cent. of their members enlisted in the Union armies, and the financial resources of the gymnastic societies and of the female auxiliaries were taxed to the utmost in aiding the families of their members who were in the army and in caring for the widows and orphans of those who had been killed. Every member of a *turnverein* is required to become a naturalized citizen of the United States. As Ling in Sweden and Jahn in Prussia organized their gymnastic societies from motives of patriotism, so, as we have just seen, the Turners in the United States were organized. At present they have 237 unions with about 40,000 members, and stand for all that is best in government, education, morals and good citizenship. The basis of their work is a sound physical education.

The growing interest in humaniculture can not truthfully be said to be due to a passing fashion. On the contrary, it is a part of a mighty movement, and like other great movements in human evolution, it is worthy of serious study. Not simply in its more obvious relations, but in its bearing upon other movements and other influences in human progress. As man is now advancing, in self discipline, in

[2] The circulation of journals devoted to health and hygiene has increased in this country until one of the best known is said to issue 300,000 copies each month.

charity, and in civic virtue, in short, as he is passing out of the age of individualism into that of fraternalism, evidence is abundant on every side that the body beautiful, the visible expression of a strong and lofty soul, shall no longer be neglected and its care and development left to chance or ignorance. Physical education and civic virtue, which is but an active demonstration of the love of one's fellows, are advancing with equal step. Charity, patience and courage are the attributes of the well-trained and vigorous physique, and these traits of character are daily becoming more common.

Instances similar to those appearing in this paper probably might be multiplied indefinitely, yet enough have been cited, it seems to me, to prove the contention that in nearly every quarter of the earth, pagan and Christian alike, are to be perceived unmistakable signs of the approach of a general "physical renaissance such as the world has only seen twice, or perhaps thrice, and which preceded the most brilliant periods in the intellectual history of mankind." In spite of the lamentations which we so often hear of the sordidness and vulgarity of modern life, of the brazen display of wealth and the venality of public men, there are not wanting many signs that the tide is setting in toward a higher and a nobler manhood and a purer, simpler and more wholesome life, and not the least of these signs is the evidence just cited, gathered from many different sources, that the physical conscience is again, after slumbering for 2,000 years, awaking and asserting itself, and will rule the world again as it did in ancient Greece.

If the coming man will listen to its voice it will lead him into a civilization that will surpass that of Greece by as much as the present age surpasses that of Pericles in the "solid progress of the sciences and their application to the useful arts."

PROBABILITY, THE FOUNDATION OF EUGENICS[1]

By FRANCIS GALTON, F.R.S.
LONDON

THE request so honorable to myself, to be the Herbert Spencer lecturer of this year, aroused a multitude of vivid recollections. Spencer's strong personality, his complete devotion to a self-imposed and life-long task, together with rare gleams of tenderness visible amidst a wilderness of abstract thought, have left a unique impression on my mind that years fail to weaken.

I do not propose to speak of his writings; they have been fully commented on elsewhere, but I desire to acknowledge my personal debt to him, which is large. It lies in what I gained through his readiness to discuss any ideas I happened to be full of at the time, with quick sympathy and keen criticism. It was his custom for many afternoons to spend an hour or two of rest in the old smoking room of the Athenæum Club, strolling into an adjoining compartment for a game of billiards when the table was free. Day after day on those afternoons I enjoyed brief talks with him, which were often of exceptional interest to myself. All that kind of comfort and pleasure has long ago passed from me. Among the many things of which age deprives us, I regret few more than the loss of contemporaries. When I was young I felt diffident in the presence of my seniors, partly owing to a sense that the ideas of the young can not be in complete sympathy with those of the old. Now that I myself am old it seems to me that my much younger friends keenly perceive the same difference, and I lose much of that outspoken criticism which is an invaluable help to all who investigate.

History of Eugenics

It must have surprised you as it did myself to find the new word "Eugenics" in the title both of the Boyle lecture, delivered in Oxford about a fortnight ago, and of this. It was an accident, not a deliberate concurrence, and I accept it as a happy omen. The field of eugenics is so wide that there is no need for myself, the second lecturer, to plant my feet in the footsteps of the first; on the contrary, it gives freedom by absolving me from saying much that had to be said in one way or another. I fully concur in the views so ably presented by my friend and co-adjutor Professor Karl Pearson, and am glad to be dispensed from further allusion to subjects that formed a large portion

[1] The Herbert Spencer lecture delivered at Oxford University on June 5, 1907.

of his lecture, on which he is a far better guide and an infinitely higher authority than myself.

In giving the following sketch of the history of eugenics I am obliged to be egotistical, because I kindled the feeble flame that struggled doubtfully for a time until it caught hold of adjacent stores of suitable material, and became a brisk fire, burning freely by itself, and again because I have had much to do with its progress quite recently.

The word "eugenics" was coined and used by me in my book "*Human Faculty*," published as long ago as 1883, which has long been out of print; it is, however, soon to be re-published in a cheap form. In it I emphasized the essential brotherhood of mankind, heredity being to my mind a very real thing; also the belief that we are born to act, and not to wait for help like able-bodied idlers, whining for doles. Individuals appear to me as finite detachments from an infinite ocean of being, temporarily endowed with executive powers. This is the only answer I can give to myself in reply to the perpetually recurring questions of "Why? whence? and whither?" The immediate "whither?" does not seem wholly dark, as some little information may be gleaned concerning the direction in which nature, so far as we know of it, is now moving. Namely, towards the evolution of mind, body and character in increasing energy and co-adaptation.

I have often wondered that the poem of Hyperion, by Keats—that magnificent torso of an incompleted work—has not been placed in the very forefront of past speculations on evolution. Keats is so thorough that he makes the very divinities to be its product. The earliest gods such as Cœlus, born out of Chaos, are vague entities, they engender Saturn, Oceanus, Hyperion, and the Titan brood, who superseded them. These in their turn are ousted from dominion by their own issue, the Olympian Gods. A notable advance occurs at each successive stage in the quality of the divinities. When Hyperion, newly terrified by signs of impending overthrow, lies prostrate on the earth "his ancient mother, for some comfort yet," the voice of Cœlus from the universal space, thus "whispered low and solemn in his ear . . . yet do thou strive for thou art capable . . . my life is but the life of winds and tides, no more than winds and tides can I prevail, but thou canst." I have quoted only disjointed fragments of this wonderful poem, enough to serve as a reminder to those who know it, but will add ten consecutive lines from the speech of the fallen Oceanus to his comrades, which give a summary of evolution as here described:

> **As Heaven and Earth are fairer, fairer far**
> **Than Chaos and black Darkness, though once chiefs,**
> **And as we show beyond that Heaven and Earth**
> **In form and shape compact and beautiful,**
> **In Will, in action free, companionship,**

> And thousand other signs of purer life;
> So on our heels a fresh perfection treads
> A power more strong in beauty, born of us
> And fated to excel us, as we pass
> In glory that old Darkness.

He ends with "this is the truth, and let it be your balm." The poem is a noble conception, founded on the crude cosmogony of the ancient Greeks.

The ideas have long held my fancy that we men may be the chief, and perhaps the only executives on earth. That we are detached on active service with, it may be only illusory, powers of free-will. Also that we are in some way accountable for our success or failure to further certain obscure ends, to be guessed as best we can. That though our instructions are obscure they are sufficiently clear to justify our interference with the pitiless course of nature, whenever it seems possible to attain the goal towards which it moves, by gentler and kindlier ways. I expressed these views as forcibly as I then could in the above-mentioned book, with especial reference to improving the racial qualities of mankind, in which the truest piety seems to me to reside in taking action, and not in submissive acquiescence to the routine of nature. It was thought impious at one time to attach lightning conductors to churches, as showing a want of trust in the tutelary care of the deity to whom they were dedicated; now I think most persons would be inclined to apply some contemptuous epithet to such as obstinately refused, on those grounds, to erect them.

The direct pursuit of studies in eugenics, as to what could practically be done, and the amount of change in racial qualities that could reasonably be anticipated, did not at first attract investigators. The idea of effecting an improvement in that direction was too much in advance of the march of popular imagination, so I had to wait. In the meantime I occupied myself with collateral problems, more especially with that of dealing measurably with faculties that are variously distributed in a large population. The results were published in my "Natural Inheritance" in 1889, and I shall have occasion to utilize some of them later on, in this very lecture. The publication of that book proved to be more timely than the former. The methods were greatly elaborated by Professor Karl Pearson, and applied by him to biometry. Professor Weldon of this university, whose untimely death is widely deplored, aided powerfully. A new science was thus created primarily on behalf of biometry, but equally applicable to eugenics, because their provinces overlap.

The publication of *Biometrika,* in which I took little more than a nominal part, appeared in 1901.

Being myself appointed Huxley lecturer before the Anthropological Institute in 1901 I took for my title "The Possible Improvement of

the Human Breed under the Existing Conditions of Law and Sentiment" (*Nature,* November 1, 1901, *Report of the Smithsonian Institution, Washington,* for the same year).

The next and a very important step towards eugenics was made by Professor Karl Pearson in his Huxley lecture of 1903 entitled "The Laws of Inheritance in Man" (*Biometrika,* Vol III.). It contains a most valuable compendium of work achieved and of objects in view; also the following passage (p. 159), which is preceded by forcible reasons for his conclusions:

> We are ceasing as a nation to breed intelligence as we did fifty to a hundred years ago. The mentally better stock in the nation is not reproducing itself at the same rate as it did of old; the less able, and the less energetic are more fertile than the better stocks. No scheme of wider or more thorough education will bring up, in the scale of intelligence, hereditary weakness to the level of hereditary strength. The only remedy, if one be possible at all, is to alter the relative fertility of the good and the bad stocks in the community.

Again in 1904, having been asked by the newly-formed Sociological Society to contribute a memoir, I did so on "Eugenics, its Definition, Aim and Scope." This was followed up in 1905 by three memoirs, "Restrictions in Marriage," "Studies in National Eugenics" and "Eugenics as a Factor in Religion," which were published in the memoirs of that society with comments thereon by more than twenty different authorities (*Sociological Papers,* published for the Sociological Society (Macmillan), Vols. I. and II.). The subject of eugenics being thus formally launched, and the time appearing ripe, I offered a small endowment to the University of London to found a research fellowship on its behalf. The offer was cordially accepted, so eugenics gained the recognition of its importance by the University of London, and a home for its study in University College. Mr. Edgar Schuster, of this university, became research fellow in 1905, and I am much indebted to his care in nurturing the young undertaking and for the memoirs he has contributed, part of which must remain for a short time longer unpublished.

When the date for Mr. Schuster's retirement approached, it was advisable to utilize the experience so far gained in reorganizing the office. Professor Pearson and myself, in consultation with the authorities of the University of London, elaborated a scheme at the beginning of this year, which is a decided advance, and shows every sign of vitality and endurance. Mr. David Heron, a mathematical scholar of St. Andrews, is now a research fellow; Miss Ethel Elderton, who has done excellent and expert work from the beginning, is deservedly raised to the position of research scholar; and the partial services of a trained computer have been secured. An event of the highest importance to the future of the office is that Professor Karl Pearson has undertaken, at my urgent request, that general supervision of its work which advancing age and infirmities preclude me from giving. He

will, I trust, treat it much as an *annexe* to his adjacent biometric laboratory, for many studies in eugenics might, with equal propriety, be carried on in either of them, and the same methods of precise analysis which are due to the mathematical skill and untiring energy of Professor Pearson are used in both. The office now bears the name of the Eugenics Laboratory, and its temporary home is in 88 Gower Street. The phrase "national eugenics" is defined as "the study of agencies under social control that may improve or impair the racial qualities of future generations, either physically or mentally."

The laboratory has already begun to publish memoirs on its own account, and I now rest satisfied in the belief that, with a fair share of good luck, this young institution will prosper and grow into an important center of research.

Application of Theories of Probability to Eugenics.

Eugenics seeks for quantitative results. It is not contented with such vague words as "much" or "little," but endeavors to determine "how much" or "how little" in precise and trustworthy figures. A simple example will show the importance of this. Let us suppose a class of persons, called A, who are afflicted with some form and some specified degree of degeneracy, as inferred from personal observations, and from family history, and let class B consist of the offspring of A. We already know only too well that when the grade of A is very low, that of the average B will be below par and mischievous to the community, but how mischievous will it probably be? This question is of a familiar kind, easily to be answered when a sufficiency of facts have been collected. But a second question arises, What will be the trustworthiness of the forecast derived from averages when it is applied to individuals? This is a kind of question that is not familiar, and rarely taken into account, although it too could be answered easily as follows: The average mischief done by each B individual to the community may for brevity be called M: the mischiefs done by the several individuals differ more or less from M by amounts whose average may be called D. In other words D is the average amount of the individual deviations from M. D thus becomes the measure of untrustworthiness. The smaller D is, the more precise the forecast, and the stronger the justification for taking such drastic measures against the propagation of class B as would be consonant to the feelings if the forecast were known to be infallible. On the other hand, a large D signifies a corresponding degree of uncertainty, and a risk that might be faced without reproach through a sentiment akin to that expressed in the maxim "It is better that many guilty should escape than that one innocent person should suffer." But that is not the sentiment by which natural selection is guided, and it is dangerous to yield far to it.

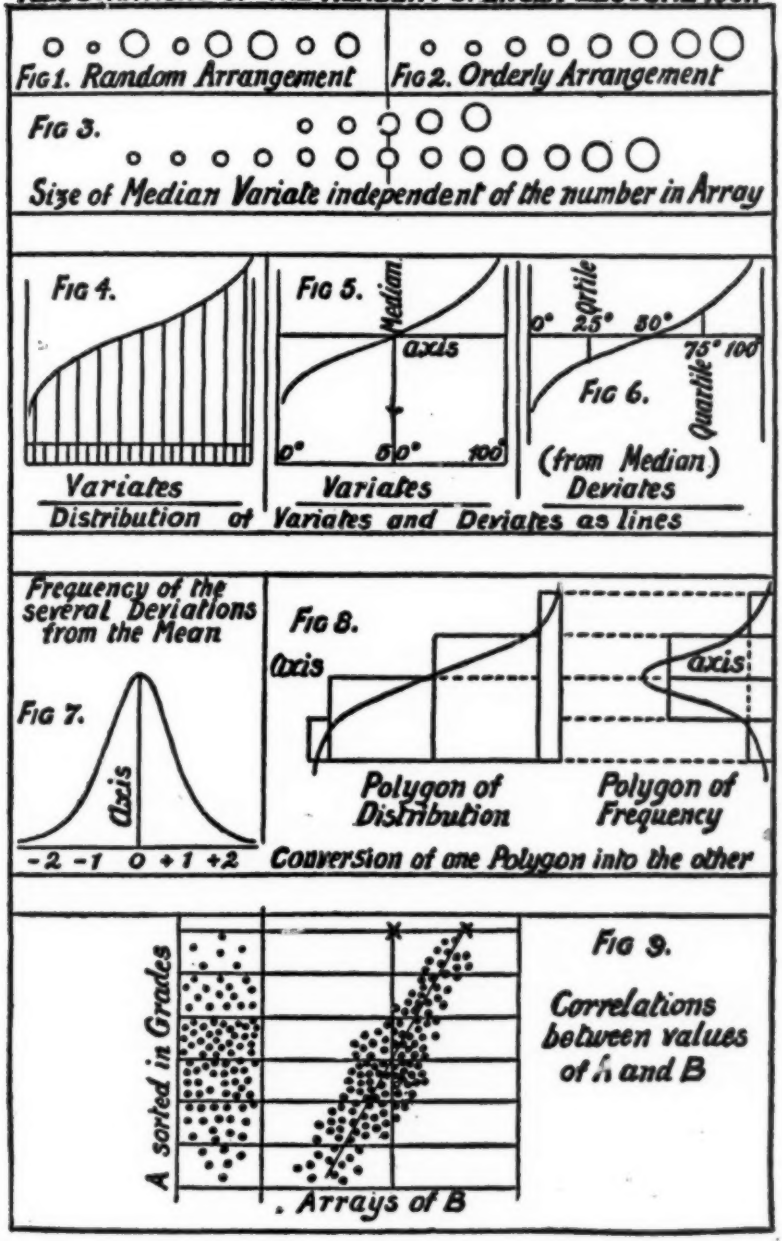
There can be no doubt that a thorough investigation of the kind described, even if confined to a single grade and to a single form of degeneracy, would be a serious undertaking. Masses of trustworthy material must be collected, usually with great difficulty, and be afterwards treated with skill and labor by methods that few at present are competent to employ. An extended investigation into the good or evil done to the state by the offspring of many different classes of persons, some of civic value, others the reverse, implies a huge volume of work sufficient to occupy eugenics laboratories for an indefinite time.

Object Lessons in the Methods of Biometry.

I propose now to speak of those fundamental principles of the laws of probability that are chiefly concerned in the newer methods of biometry, and consequently of eugenics. Most persons of ordinary education seem to know nothing about them, not even understanding their technical terms, much less appreciating the cogency of their results. This popular ignorance so obstructs the path of eugenics that I venture to tax your attention by proposing a method of partly dispelling it. Let me first say that no one can be more conscious than myself of the large amount of study that is required to qualify a man to deal adequately with the mathematical methods of biometry, or that any man can hope for much success in that direction unless he is possessed of appropriate faculties and a strong brain. On the other hand, I hold an opinion, likely at first sight to scandalize biometricians and which I must justify, that the fundamental ideas on which abstruse problems of probability are based admit of being so presented to any intelligent person as to be grasped by him, even though he be quite ignorant of mathematics. The conditions of doing so are that the lessons shall be as far as possible "object lessons," in which real objects shall be handled as in the kindergarten system, and simple operations performed and not only talked about. I am anxious to make myself so far understood that some teachers of science may be induced to elaborate the course that I present now only in outline. It seems to me suitably divisible into a course of five lessons of one hour each, which would be sufficient to introduce the learner into a new world of ideas, extraordinarily wide in their application. A proper notion of what is meant by correlation requires some knowledge of the principal features of variation, and will be the goal towards which the lessons lead.

To most persons variability implies something indefinite and capricious. They require to be taught that it, like Proteus in the old fable, can be seized, securely bound, and utilized; that it can be defined and measured. It was disregarded by the old methods of statistics, that concerned themselves solely with averages. The average amount of various measurable faculties or events in a multitude of

ILLUSTRATIONS OF THE HERBERT SPENCER LECTURE 1907.



persons was determined by simple methods, the individual variations being left out of account as too difficult to deal with. A population was treated by the old methods as a structureless atom, but the newer methods treat it as a compound unit. It will be a considerable intellectual gain to an otherwise educated person, to fully understand the way in which this can be done, and this and such like matters the proposed course of lessons is intended to make clear. It can not be expected that in the few available minutes more than an outline can be given here of what is intended to be conveyed in perhaps thirty-fold as much time with the aid of profuse illustrations by objects and diagrams. At the risk of being wearisome, it is, however, necessary to offer the following syllabus of what is proposed, for an outline of what teachers might fill in.

The object of the first lesson would be to explain and illustrate variability of size, weight, number, etc., by exhibiting samples of specimens that had been marshalled at random (Fig. 1), or arrayed in order of their magnitude (Fig. 2). Thus when variations of length were considered, objects of suitable size, such as chestnuts, acorns, hazelnuts, stones of wall fruit, might be arrayed as beads on a string. It will be shown that an "array" of variates of any kind falls into a continuous series. That each variate differs little from its neighbors about the middles of the arrays, but that such differences increase rapidly towards their extremities. Abundant illustration would be required, and much handling of specimens.

Arrays of variates of the same class strung together, differing considerably in the number of the objects they each contain, would be laid side by side and their middle-most variates or "medians" (Fig. 3) would be compared. It would be shown that as a rule the medians become very similar to one another when the numbers in the arrays are large. It must then be dogmatically explained that double accuracy usually accompanies a four-fold number, a treble accuracy a nine-fold number, and so on.

(This concludes the first lesson, during which the words and significations of variability, variate array, and median will have been learned.)

The second lesson is intended to give more precision to the idea of an array. The variates in any one of these strung loosely on a cord, should be disposed at equal distances apart in front of an equal number of compartments, like horses in the front of a row of stalls (Fig. 4), and their tops joined. There will always be one more side to the row of stalls than there are objects, otherwise a side of one of the extreme stalls would be wanting. Thus there are two ways of indicating the portion of a particular variate, either by its *serial number* as "first," "second," "third," or so on, or by *degrees* like those of a thermometer.

In the latter case the sides of the stalls serve as degrees, counting the first of them as 0°, making one more graduation than the number of objects, as should be. The difference between these two methods has to be made clear, and that while the serial position of the median object is always the same in any two arrays whatever be the number of variates, the serial positions of their subdivisions can not be the same, the ignored half interval at either end varying in width according to the number of variates, and becoming considerable when that number is small.

Lines of proportionate length will then be used drawn on a blackboard, and the limits of the array will be also drawn, at a half interval from either end. The base is then to be divided centesimally.

Next join the tops of the lines with a smooth curve, and wipe out everything except the curve, the limit at either side, and the centestimally divided base (Fig. 5). This figure forms a scheme of distribution of variates. Explain clearly that its shape is independent of the number of variates, so long as they are sufficiently numerous to secure statistical constancy.

Show numerous schemes of variates of different kinds, and remark on the prevalent family likeness between the bounding curves. (Words and meanings learnt—schemes of distribution, centesimal graduation of base.)

The third lesson passes from variates, measured upwards from the base, to deviates measured upwards or downwards from the median, and treated as positive or negative values accordingly (Fig. 6).

Draw a scheme of variates on the blackboard, and show that it consists of two parts; the median which represents a constant, and the curve which represents the variations from it. Draw a horizontal line from limit to limit, through the top of the median, to serve as axis to the curve. Divide the axis centesimally, and wipe out everything except curve, axis and limits. This forms a scheme of distribution of deviates. Draw ordinates from the axis to the curve at the twenty-fifth and seventy-fifth divisions. These are the "quartile" deviates.

At this stage the genesis of the theoretical normal curve might be briefly explained and the generality of its application; also some of its beautiful properties of reproduction. Many of the diagrams already shown would be again employed to show the prevalence of approximately normal distributions. Exceptions of strongly marked skew curves would be exhibited and their genesis briefly explained.

It will then be explained that while the ordinate at *any* specified centesimal division in two normal curves measures their relative variability, the quartile is commonly employed as the unit of variability under the almost grotesque name of "probable error," which is intended to signify that the length of any deviate in the system is as likely as

not to exceed or to fall short of it. This, by construction, is the case of either quartile.

(New words and meanings—scheme of distribution of deviates, axis, normal, skew, quartile and probable error.)

In the fourth lesson it has to be explained that the curve of normal distribution is not the direct result of calculation, neither does the formula that expresses it lend itself so freely to further calculation, as that of frequency. Their shapes differ; the first is an ogive, the second (Fig. 7) is bell-shaped. In the curve of freqency the derivations are reckoned from the mean of all the variates, and not from the median. Mean and median are the same in normal curves, but may differ much in others. Either curve can be transformed into the other, as is best exemplified by using a polygon (Fig. 8) instead of the curve, consisting of a series of rectangles differing in height by the same amounts, but having widths respectively representative of the frequencies of 1, 3, 3, 1. (This is one of those known as a binomial series, whose genesis might be briefly explained.) If these rectangles are arrayed in order of their widths, side by side, they become the equivalents of the ogival curve of distribution. Now if each of these latter rectangles be slid parallel to itself up to either limit, their bases will overlap and they become equivalent to the bell-shaped curve of frequency with its base vertical.

The curve of frequency contains no easily perceived unit of variability like the quartile of the curve of distribution. It is therefore not suited for and was not used as a first illustration, but the formula that expresses it is by far the more suitable of the two for calculation. Its unit of variability is what is called the "standard deviation," whose genesis will admit of illustration. How the calculations are made for finding its value is beyond the reach of the present lessons. The calculated ordinates of the normal curve must be accepted by the learner much as the time of day by his watch, though he be ignorant of the principles of its construction. Much more beyond his reach are the formulæ used to express quasi-normal and skew curves. They require a previous knowledge of rather advanced mathematics.

(New words and ideas—curve of frequency, standard deviation, mean, binomial series.)

The fifth and last lesson deals with the measurement of correlation, that is, with the closeness of the relation between any two systems whose variations are due partly to causes common to both, and partly to causes special to each. It applies to nearly every social relation, as to environment and health, social position and fertility, the kinship of parent to child, of uncle to nephew, etc. It may be mechanically illustrated by the movements of two pulleys with weights attached,

suspended from a cord held by one of the hands of three different persons, 1, 2, and 3. No. 2 holds the middle of the cord, one half of which then passes round one of the pulleys up to the hand of No. 1; the other half similarly round the other pulley up to the hand of No. 3. The hands of Nos. 1, 2 and 3 move up and down quite independently, but as the movements of both weights are simultaneously controlled in part by No. 2, they become "correlated."

The formation of a table of correlations on paper ruled in squares, is easily explained on the blackboard (Fig. 9). The pairs of correlated values *A* and *B* have to be expressed in units of their respective variabilities. They are then sorted into the squares of the paper,—vertically according to the magnitudes of *A*, horizontally according to those of *B*—, and the mean of each partial array of *B* values, corresponding to each grade of *A*, has to be determined. It is found theoretically that where variability is normal, the means of *B* lie practically in a straight line on the face of the table, and observation shows they do so in most other cases. It follows that the average deviation of a *B* value bears a constant ratio to the deviation of the corresponding *A* value. This ratio is called the "index of correlation," and is expressed by a single figure. For example: if the thigh-bones of many persons deviate "very much" from the usual length of the thigh-bones of their race, the average of the lengths of the corresponding arm-bones will differ "much," but not "very much," from the usual length of arm-bones, and the ratio between this "very much" and "much" is constant and in the same direction, whatever be the numerical value attached to the word "very much." Lastly, the trustworthiness of the index of correlation, when applied to individual cases, is readily calculable. When the closeness of correlation is absolute, it is expressed by the number 1·0, and by 0·0, when the correlation is nil.

(New words and ideas—correlation and index of correlation.)

This concludes what I have to say on these suggested object lessons. It will have been tedious to follow in its necessarily much compressed form but will serve, I trust, to convey its main purpose of showing that a very brief course of lessons, copiously illustrated by diagrams and objects to handle, would give an acceptable introduction to the newer methods employed in biometry and in eugenics. Further, that when read leisurely by experts in its printed form, it would give quite sufficient guidance for elaborating details.

Influence of Collective Truths upon Individual Conduct.

We have thus far been concerned with probability, determined by methods that take cognizance of variations, and yield exact results, thereby affording a solid foundation for action. But the stage on which

human action takes place is a superstructure into which emotion enters, we are guided on it less by certainty and by probability than by assurance to a greater or lesser degree. The word assurance is derived from *sure,* which itself is an abbreviation of *secure,* that is, of *se- cura,* or without misgiving. It is a contented attitude of mind largely dependent on custom, prejudice, or other unreasonable influences which reformers have to overcome, and some of which they are apt to utilize on their own behalf. Human nature is such that we rarely find our way by the pure light of reason, but while peering through spectacles furnished with colored and distorting glasses.

Locke seems to confound certainty with assurance in his forcible description of the way in which men are guided in their daily affairs ("Human Understanding," IV., 14, par. 1):

> Man would be at a great loss if he had nothing to direct him but what has the certainty of true knowledge. For that being very short and scanty, he would be often utterly in the dark, and in most of the actions of his life, perfectly at a stand, had he nothing to guide him in the absence of clear and certain knowledge. He that will not eat till he has demonstration that it will nourish him, he that will not stir till he infallibly knows the business he goes about will succeed, will have little else to do but to sit still and perish.

A society may be considered as a highly complex organism, with a consciousness of its own, caring only for itself, establishing regulations and customs for its collective advantage, and creating a code of opinions to subserve that end. It is hard to over-rate its power over the individual in regard to any obvious particular on which it emphatically insists. I trust in some future time that one of those particulars will be the practise of eugenics. Otherwise the influence of collective truths on individual conduct is deplorably weak, as expressed by the lines:

> For others' follies teach us not,
> Nor much their wisdom teaches,
> But chief of solid worth is what
> Our own experience preaches.

Professor Westermark, among many other remarks in which I fully concur, has aptly stated (*Sociological Papers,* published for the Sociological Society. Macmillan, 1906, Vol. II., p. 24), with reference to one obstacle which prevents individuals from perceiving the importance of eugenics, "the prevalent opinion that almost anybody is good enough to marry is chiefly due to the fact that in this case, cause and effect, marriage and the feebleness of the offspring, are so distant from each other that the *near-sighted eye* does not distinctly perceive the connection between them." (The Italics are mine.)

The enlightenment of individuals is a necessary preamble to practical eugenics, but social opinion is the tyrant by whose praise or blame the principles of eugenics may be expected hereafter to influence individual conduct. Public opinion may, however, be easily directed into different channels by opportune pressure. A common conviction

that change in the established order of some particular codes of conduct would be impossible, because of the shock that the idea of doing so gives to our present ideas, bears some resemblance to the conviction of lovers that their present sentiments will endure for ever. Conviction, which is that very assurance of which mention has just been made, is proved by reiterated experience to be a highly fallacious guide. Love is notoriously fickle in despite of the fervent and genuine protestations of lovers, and so is public opinion. I gave a list of extraordinary variations of the latter in respect to restrictions it enforced on the freedom of marriage, at various times and places (*Sociological Papers,* quoted above). Much could be added to that list, but I will not now discuss the effects of public opinion on such a serious question. I will take a much smaller instance which occurred before the time to which the recollections of most persons can now reach, but which I myself recall vividly. It is the simple matter of hair on the face of male adults. When I was young, it was an unpardonable offence for any English person other than a cavalry officer, or perhaps some one of high social rank, to wear a moustache. Foreigners did so and were tolerated, otherwise the assumption of a moustache was in popular opinion worse than wicked, for it was atrociously bad style. Then came the Crimean War and the winter of Balaclava, during which it was cruel to compel the infantry to shave themselves every morning. So their beards began to grow, and this broke a long established custom. On the return of the army to England the fashion of beards spread among the laity, but stopped short of the clergy. These, however, soon began to show dissatisfaction, they said the beard was a sign of manliness that ought not to be suppressed and so forth; and at length the moment arrived. A distinguished clergyman, happily still living, "bearded" his bishop on a critical occasion. The bishop yielded without protest, and forthwith hair began to sprout in a thousand pulpits where it had never appeared before within the memory of man.

It would be no small shock to public sentiment if our athletes in running public races were to strip themselves stark naked, yet that custom was rather suddenly introduced into Greece. Plato says (Republic V., par. 452, Jowett's translation):

> Not long ago the Greeks were of the opinion, which is still generally received among the barbarians, that the sight of a naked man was ridiculous and improper, and when first the Cretans and the Lacedæmonians introduced naked exercises, the wits of that day might have ridiculed them. . . .

Thucydides (I. 6) also refers to the same change as occurring "quite lately."

Public opinion is commonly far in advance of private morality, because society as a whole keenly appreciates acts that tend to its advantage, and condemns those that do not. It applauds acts of heroism

that perhaps not one of the applauders would be disposed to emulate. It is instructive to observe cases in which the benevolence of public opinion has outstripped that of the law—which, for example, takes no notice of such acts as are enshrined in the parable of the good Samaritan. A man on his journey was robbed, wounded, and left by the wayside. A priest and a Levite successively pass by and take no heed of him. A Samaritan follows, takes pity, binds his wounds, and bears him to a place of safety. Public opinion keenly condemns the priest and the Levite, and praises the Samaritan, but our criminal law is indifferent to such acts. It is most severe on misadventure due to the neglect of a definite duty, but careless about those due to absence of common philanthropy. Its callousness in this respect is painfully shown in the following quotations (Kenny, "Outlines of Criminal Law," 1902, p. 121, per Hawkins in Reg. v. Paine, *Times*, February 25, 1880):

> If I saw a man who was not under my charge, taking up a tumbler of poison, I should not be guilty of any crime by not stopping him. I am under no legal obligation to protect a stranger.

That is probably what the priest and the Levite of the parable said to themselves.

A still more emphatic example is in the "Digest of Criminal Law," by Justice Sir James Stephen, 1887, p. 154. Reg. v. Smith, 2 C. and P., 449:

> *A* sees *B* drowning and is able to help him by holding out his hand. *A* abstains from doing so in order that *B* may be drowned, and *B* is drowned. *A* has committed no offence.

It appears, from a footnote, that this case has been discussed in a striking manner by Lord Macaulay in his notes on the Indian Penal Code, which I have not yet been able to consult.

Enough has been written elsewhere by myself and others to show that whenever public opinion is strongly roused it will lead to action, however contradictory it may be to previous custom and sentiment. Considering that public opinion is guided by the sense of what best serves the interests of society as a whole, it is reasonable to expect that it will be strongly exerted in favor of eugenics when a sufficiency of evidence shall have been collected to make the truths on which it rests plain to all. That moment has not yet arrived. Enough is already known to those who have studied the question to leave no doubt in their minds about the general results, but not enough is quantitatively known to justify legislation or other action except in extreme cases. Continued studies will be required for some time to come, and the pace must not be hurried. When the desired fullness of information shall have been acquired, then, and not till then, will be the fit moment to proclaim a "Jehad," or Holy War against customs and prejudices that impair the physical and moral qualities of our race.

SOME LITTLE-KNOWN MEXICAN VOLCANOES

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WHILE the inhabitants of the United States were suffering from the heat of an unusual summer, the members of the International Geological Congress were making a study of the geology of the plateau region of Mexico and were enjoying the delightful climate of that country. Few regions of the world are more fascinating; the combination of vast volcanic peaks, broad arid plains, with their curious desert flora and a brilliant tropical sky, leaves an impression never to be forgotten.

It was in the midst of such interesting surroundings that during August, September and October, 1906, the International Congress of Geologists met, and, as a member, the writer had an opportunity to visit several of the Mexican volcanoes under especially favorable circumstances. In the first place, the guides to the various volcanoes were trained geologists of the Mexican Geological Survey, who had previously made a study of the regions to which they conducted the party. Moreover, the personnel of the visitors embraced geologists from Europe and America, who had investigated volcanoes in many parts of the world, and consequently, by way of comparison, were able to add a great deal of interesting information.

If you will look at a map of Mexico, you will notice that the names Volcano Colima, Nevado de Toluca and Valle de Santiago form the vertices of an obtuse triangle west of the City of Mexico. With these three points we will concern ourselves.

Volcano Colima

Volcano Colima, the most recently active volcano in Mexico, whose cloud-crowned summit can be seen for many miles along the Pacific coast, is situated almost due west of Mexico city and about fifty miles from the Pacific Ocean. It can be reached without much difficulty from the village of Zapotlan by a horseback journey of ten hours. On the ride one winds along the sharp divides which separate deep ravines, around the high Nevado, and finally reaches the foot of the cone from which the climb on foot must begin.

A more beautifully symmetrical volcanic cone than that of Colima, as viewed from the north, can hardly be imagined; the only feature breaking the symmetry being a secondary cone which arises from the northeast slope. The beauty of the cone is enhanced by the great clouds

of steam which, continually arising from the crater, either envelop the summit or, blown by the wind, stretch out into long white clouds.

FIG. 1. SECONDARY CONE AND LAVA FLOW OF 1869.

FIG. 2. VOLCANO COLIMA WITH SECONDARY CONE.

The altitude of the principal cone is a little less than 12,600 feet above sea-level, while the top of the secondary cone is 780 feet lower.

The Lava Flow of 1869.—One of the chief difficulties in ascending Colima from the north side is the necessity of crossing the rough lava flow which was poured out from the secondary cone in 1869. The north side of this flow is very precipitous, as its highest point rises considerably above that of the central portion of the flow, thus forming a kind of wall on the north side. A more rapid cooling of the outer edge of

FIG. 3. THE NEVADO OF COLIMA.

the molten lava stream than that of the center formed this wall. As a result the sides hardened rapidly and consequently have an altitude about equal to that of the stream at its greatest height. The central portion, remaining hot for a longer time, flowed on after the lava had ceased to flow from the cone, and thus lowered its surface. In August, 1869, a month after the principal eruption, the lava is said to have flowed a little more than nine feet per day. The surface of this lava is as scoriaceous, irregular and crumbly (*aa*), as one can well imagine, but does not differ greatly from the *mal pais* seen in other parts of Mexico. Because of this character, one is obliged to walk with the greatest care, stepping over or descending into fissures, climbing up or over irregular masses of scoriæ. Indeed, the roughness of the lava hurts the hands and tears the shoes, and its treacherous character compels one to be on the alert at all times, which makes the work very exhausting.

Secondary Cone.—The secondary cone is composed of a compact though somewhat vesicular andesite with a steep slope. From this cone, as has been said, lava poured forth in 1869. There is no crater in the cone, although the summit is broken by three parallel fissures.

This fissuring may have been the result of shrinkage by cooling or it may have been due to a sinking of the lava in the cone. It seems probable that the secondary cone was formed as follows: Previous to the eruption of 1869, the pressure from below fissured the main cone. Through this fissure the lava welled up, flowing away as a lava stream. The stiffer and cooler lava, which was later forced up, failed to flow, and hardened to form the mound.

FIG. 4. CRATER COLIMA, SEPTEMBER, 1906.

The Main Cone.—The ascent of the main cone is difficult because of the insecure footing afforded by the rolling ash and cinders and the steepness of the lava wherever it outcrops, as well as because of the altitude. The slope of the cone is between 35 and 39 degrees, although from a distance it appears to be much greater.

The Crater.—The rim of the crater is entire with the exception of a depression through which a lava stream flowed in 1885 and again in 1903. The view into the crater from the higher portions of its rim is very impressive, even awe-inspiring. The slope on the outside of the rim is that of the volcano, but the inside drops precipitously to the bottom of the crater, a depth of more than 100 feet in many places. On account of the great quantities of steam which are continually rising,

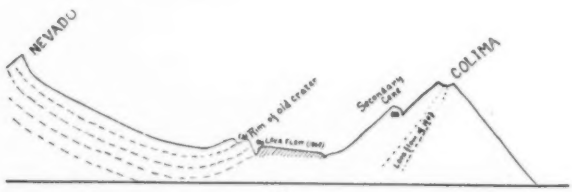


FIG. 5. CROSS SECTION, SHOWING THE RELATIONS OF THE SECONDARY TO THE MAIN CONE.

it is only when an occasional gust of wind partially lifts the steam that one can get a glimpse of the floor of the crater. Descent into the crater by way of the breach in the side is comparatively easy and is attended with less danger than the view from the rim prophesied. The floor is covered with scoriaceous lava equaling, if not exceeding, in ruggedness that of the lava flow at the foot of the volcano. Steam with a tem-

perature of about 130 degrees Fahrenheit and sulphur dioxide are issuing from numerous fumaroles, some of which are lined with sulphur crystals. The crater is comparatively small, having a diameter of little over half a mile.

Recent Eruptions.—In 1877, 1884 and 1885 minor eruptions occurred. The last eruption of the volcano commenced in the month of February, 1903, and practically ceased in May of the same year. Since that time the only evidences of activity are the fumaroles from which issue large quantities of steam and other gases. During this eruption

FIG. 6. FLANK OF TOLUCA.

(1903) a lava stream flowed down the slope of the volcano in a northwest direction, but barely reached the foot of the volcano (see diagram), where it dammed a small stream, thus forming a shallow pond.

The accompanying diagrammatic cross-section of the volcano shows the relations of the secondary cone to the main cone, the position of the lava flow of 1869, the edge of this flow (*a*), the rim of the old crater (*b*), the lava flow of 1903, and the position and relative heights of Colima and the Nevado of Colima (which may have been the remnant of the rim of a great volcano long since destroyed). In the construction of this diagram, no attempt was made to draw the distances or heights to scale, but to bring out the salient points as clearly as possible.

VOLCANO TOLUCA

In the midst of the valley of Toluca, the Nevado of Toluca (Xinantecatl) towers almost 6,000 feet above the level of the plain and 14,833

FIG. 7. BARRANCA SHOWING STRATIFIED TUFF AND FOSSIL SOIL.

feet above the sea. It is called the Nevado, because usually its summit is white with snow. This volcano is isolated, being surrounded at some distance by volcanoes which have formed by the accumulation of their ash and lava an almost enclosed basin. It is one of the few high volcanoes of the world that can be ascended with ease, since it is possible to make the journey to and into the crater on horseback in four or five hours. Because of the ease with which it may be climbed the ascent has been made by a number of persons, the first of whom was the great geographer and traveler Humboldt, who reached the crater in 1803.

General Description.—Volcano Toluca is underlaid by calcareous rocks of Cretaceous age. The great mass of the volcano is composed of many layers of ash of varying degrees of thickness which conform quite closely to the slope. These layers of ash were apparently formed partly by the ash which rained down during the eruptions and partly by that which was carried down by streamlets and to a considerable extent in sheets during heavy rains. The accompanying photograph shows the stratified character of the slope and also a stratum of fossil soil, which in several of the "barrancas" or dry ravines is seen to be of considerable thickness. From this evidence it is fair to conclude that the last eruptions were preceded by a long period of inactivity, during which a large quantity of organic material was mixed with the weathered ash. Toluca has not been in eruption within historic times and at present there are no signs of activity, even secondary effects, such as fumaroles of steam and sulphur dioxide, being absent.

To watch the change in vegetation from the plain to the summit of the mountain is a constant pleasure. On the dry plain cactus and other desert plants are common, but on the flanks of the mountain pines begin and many bright-colored flowers. These, as one continues the ascent, become shorter and more stunted, until in the crater the flower blossoms an inch or thereabouts from the ground instead of one or two feet from the ground, as is the case lower down. On the highest portions of the rim vegetation is almost lacking.

The Crater.—The crater of the volcano is somewhat elliptical in form, being a little more than a mile in its longest diameter and about a third of a mile in its shortest. The crater rim is complete on all sides, but is low on the side through which entrance is made. In the bottom of the crater and 1,000 feet below the highest portion of the rim are two beautifully clear lakes, the larger of which is almost one fifth of a mile in diameter and has a maximum depth of thirty feet. These two lakes are separated by a dome of compact andesite of considerable height (see illustration). This dome is of especial interest, because of its bearings upon the origin of the Mt. Pelée spike. There seems to be little doubt, as T. Flores points out, that it is composed of the lava which was forced up and out of the vent after the last eruption and which now closes it and stands above the floor of the crater.

Comparison with Mt. Pelée.—It was suggested by Dr. E. O. Hovey that the Pelée plug was formed in this way also, *i. e.*, that instead of a solid mass of lava being pushed up bodily, as Heilprin believed, very

FIG. 8. CRATER OF TOLUCA, SHOWING LAKE AND ANDESITE CONE.

stiff lava, being forced from the vent after the last eruption, hardened into a high mound. In the case of Pelée the shape of the mound was modified by a splitting off of the lava along vertical planes, which produced the unique "spike" of that volcano.

Age.—A comparison of this volcano with others in Mexico has led Ordoñez to state that it probably made its appearance during Pliocene times.

Cinder Cones of Valle de Santiago

Cinder cones a few hundred feet in height are common objects in the central volcanic plateau of Mexico. Many of these may be seen in the basin in which the City of Mexico is situated, where the lower flanks of the higher volcanoes meet the plain. Near Toluca excellent examples occur. Because of the smallness of these cones as compared with the volcanoes near whose base they rise they are likely to be overlooked on

Fig. 9. Crater Lake and Cinder Cone, Valle de Santiago, Mexico.

account of the overshadowing effect of the former. This is not true of the group of cinder cones, situated near the city Valle de Santiago, which are scattered about the valley some distance from the higher volcanoes, and which are, consequently, very conspicuous, their symmetrical truncated cones being the most marked features of the landscape.

This group of eleven craters occupies an area roughly circular in outline, one diameter of which is about six miles. Because of the fact that the valley of Santiago is a dry plain, the presence of lakes of pure water in four of the craters is unexpected. The clear blue

water of the lakes with their settings of green cultivated fields which cover the inner slopes of the craters are most beautiful objects.

The existence of these lakes is due to the fact that their bottoms are below the levels of underground water. All these crater lakes are at practically the same level, a condition which is due to the fact that the volcanic material in which they rest and of which the plain is composed is extremely porous, which permits the free circulation of the water. The craters of the majority of the cones were partially filled with lava which poured out quietly after the explosions which formed them had ceased. In some cases they were filled until their bottoms were above the level of underground water and are consequently dry; in others there was either no subsequent outpouring of lava or the quantity was very limited, in which case the cavity remained below the level of underground water and a lake resulted. The diameter of the craters vary in size from that of Solis (1,500 feet)—which was apparently produced by the sinking of the crust—to the largest, which is more than a mile in diameter. The craters are not all perfect; some are entire, while others are broken by one or two subsequent craters of explosion. In one of these breeched craters three small cones rise from the bottom, the material of which is apparently being used in the city for constructional purposes.

The plain upon which the craters rest is underlaid by one or more strata of basaltic lava which evidently flowed from the neighboring mountains and which may be seen near the water level of the lakes and in ravines which have been deeply cut by streams. Since neither this stratum nor the strata of basaltic lava are disturbed by being domed up or bent to any extent, it seems safe to conclude that the explosions forming the craters must have been near the surface and very local, otherwise the strata overlying the plain at that place would have been more or less bent.

The cones are made up in some cases of volcanic ash of various degrees of fineness, in others of volcanic breccia. The slopes are those which are normally made by such materials.

Because of the fact that craters of explosion in other parts of Mexico—Puebla, Mexico City, here in Valle de Santiago, and elsewhere in the republic—arise from a plain or a more or less enclosed basin which is full of water at a comparatively shallow depth, Ordoñez suggests that superficial water may have had a share in the production of the explosions.

Such are a few of the points of interest on the volcanic plateau of Mexico, a region which, interesting because of its scenery and climate, fascinating because of its romantic history, is to the geologist a volume which when studied will explain many points that are now a matter of speculation.

THE PROGRESS OF SCIENCE

DOES THE SPEED OF LIGHT IN SPACE DEPEND UPON ITS WAVE-LENGTH?

WHEN a beam of light comes through a prism of glass or a raindrop it is dispersed into a band of vivid colors, each denoting a particular wave-length. Though all these wave-lengths travel together in the air they part company in the glass or the water because there they no longer possess the same speed. The long waves, which produce the sensation of red, travel faster than the short, or violet waves.

Whether all wave-lengths really do travel with the same speed in air has not always been a matter of a single opinion. Lorenz and Ketteler both have found that the index of refraction for air differs by some seven parts in a million according to which end of the spectrum is employed. This means a proportionate difference in the speed of light in air for the long and for the short waves. More than a quarter of a century ago Young and Forbes, using Fizeau's method, seemed to find that the speed of the blue waves in air was 1.8 per cent. greater than that of the red ones. This result was threshed over by Lord Rayleigh, who pointed out serious objections to accepting their results. When Michelson was determining the speed of light, he paid especial attention to this question. When white light and red light were compared not the slightest trace of difference in their speeds could be detected. We may, therefore, rest assured that all waves of the visible spectrum travel with practically the same speed in air.

Now how is it in a vacuum, especially in that vast vacuum, interstellar space? If we begin by limiting our observations to our own solar system, it has been noticed that when one of its satellites goes behind Jupiter its color is just the same as when it emerges. Suppose that Young and Forbes were right and that the blue rays do travel faster than the red rays. Then when the satellite is behind the planet so that it can send no more light to the earth, the train of waves which it emitted before its eclipse, still pursues its journey toward us. If the blue waves outrun the red waves, it will be the latter which give us our last glimpse of the satellite. At disappearance it should then appear red. Similarly upon emergence the blue should be the first waves to reach the eye, but no such difference of color upon eclipse and emergence is seen. Hence we may conclude that all waves of the visible spectrum travel in space with the same speed. It is, however, well to bear in mind that the universe is larger than the solar system and that the visible spectrum by no means includes all known radiation.

In 1859 Uriah A. Borden deposited with the Franklin Institute of Philadelphia one thousand dollars to be awarded as a premium to "any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity." This problem was restated by the board of managers thus: "Whether or not all rays in the spectrum known at the time the offer was made, namely, March 23, 1859, and comprised between the lowest frequency known thermal rays in the infra-red, and the highest frequency known rays in the ultra-violet . . . travel through free space with the same velocity."

Dr. Paul R. Heyl, of the Central

High School of Philadelphia, has solved one part of this problem. He has shown that the ultra-violet waves and the waves of the visible spectrum travel with the same velocity. For this the Franklin Institute has awarded to him one thousand dollars of the accumulated fund. There has been no lack of applications for the premium, but no portion of it has ever before been awarded. The investigating committee, consisting of Mr. Hugo Bilgram, mechanical engineer; Professor A. W. Goodspeed, of the University of Pennsylvania, and Dr. G. F. Stradling, of the Northeast Manual Training High School of Philadelphia, were unanimous in their favorable opinion.

The star Algol, or β Persei, is a spectroscopic binary, that is, a study of its light shows that part of the time the star is approaching the earth and part of the time receding from it. Moreover, every 69 hours it grows less bright, only to regain its rank as a star of the second magnitude after the lapse of about 7 hours. The simplest explanation of these erratic performances is that there are two bodies, one luminous, the other opaque, revolving around their common center of mass. The dimming of brightness occurs when the opaque body gets between the earth and the luminous body. Their diameters, orbital velocities and masses have been calculated and also the distance their centers are apart.

The remoteness of Algol—it takes light 30 years to come thence to the earth—as well as its change of brightness caused it to be selected by Dr. Heyl for his investigation. In brief his method was this. He obtained records of the change of brightness of the star by photographing it at intervals in ultra-violet light produced by a transparent diffraction grating. The variation as judged by the eye was already known. If the ultra-violet waves travel faster than those belonging to the visible spectrum there would be a shifting of the time of least brightness of the image. A comparison of the two cycles of change however shows that there can not be a greater difference between the speed of the ultra-violet light and that of the visible spectrum of more than one part in 250,000.

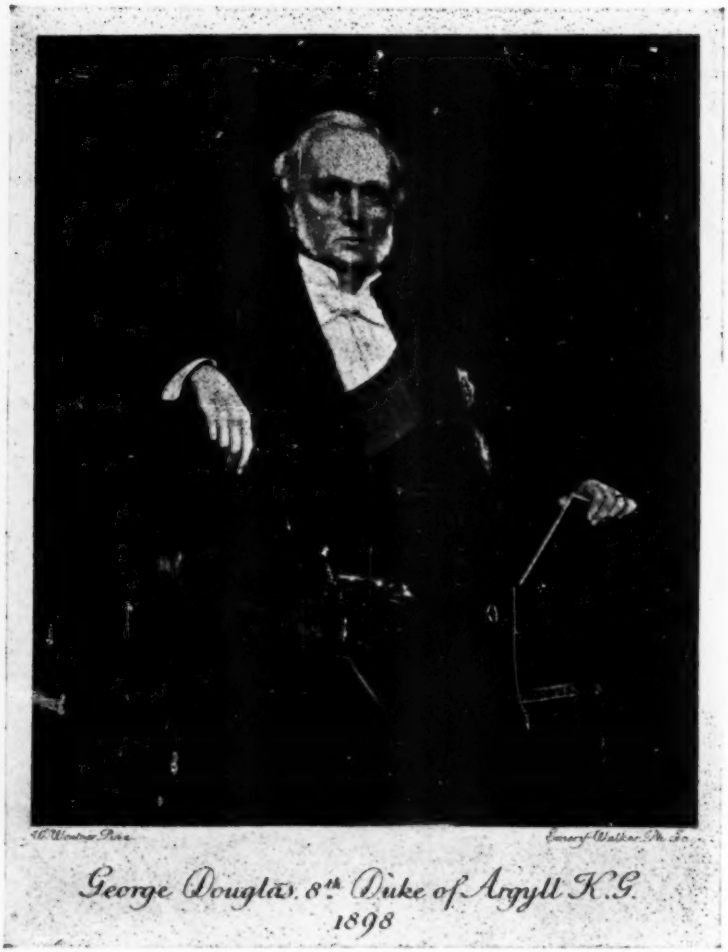
There seems to have been no previous determination of the speed of ultra-violet waves in a vacuum. Dr. Heyl's result, in substance that the two kinds of waves do not differ in speed by more than 1 km. per second, is of high value. To be sure it has been assumed for a long time that no such difference existed, but an experimental proof is a very different thing from mere extrapolation.

The work was conducted with the 8-inch equatorial of the Central High School and extended over a period of two years. The times when the variation of Algol occurred at a suitable time of day and under appropriate conditions of the sky were rare.

As yet there seems to be no experimental demonstration that the infra-red rays and those of the visible spectrum travel in space with the same speed. As far back as 1842 Wrede believed he had shown that the two speeds were different, but his work was subject to error. The method of Dr. Heyl does not lend itself to the settlement of this second part of the problem, since the infra-red rays have little effect upon a photographic plate. Let us hope that some physicist may devise an appropriate method and thus remove this gap in our knowledge of the velocity of radiation—incidentally obtaining another portion of the Boyden premium.

THE DUKE OF ARGYLE

THE autobiography and memoirs of the late Duke of Argyle, edited by his wife, have lately been published in two large volumes. Perhaps most men of science, on being asked offhand for an estimate of the duke, would reply that he was an amiable dilettante, with more enthusiasm than knowledge. In a way, this is correct enough; but given



George Douglas 8th Duke of Argyll K.G.
1898

without qualification, it does him a great injustice. He was, throughout his life, an earnest, sincere and industrious man, much interested in the advancement of his fellows and the cultivation of his own mind. Inheriting an enormous estate, and taking a most prominent part in the politics of his time, he bore on his shoulders as great a burden as a man might care to lift, without taking time and energy for scientific work. It is impossible to say what he might have done, had he devoted himself mainly to some single branch of science or literature, but one may readily believe that it would in no wise have equalled his actual achievement as a versatile man of affairs. He was not a genius, in the ordinary acceptation of the term; but he was one of those thoroughly useful citizens who serve to hold together the diverse elements of human society. In this sense, he was a duke in fact as well as in name, and an aristocracy so typified is not without a certain justification even from our democratic point of view.

Many naturalists are familiar—and some no less tired than familiar—with the duke's controversial writings on semi-metaphysical questions relating to evolution. Fewer, we imagine, know

how enthusiastically he watched the birds and other living things on his estate, and how graphically and accurately he could describe them. The following, taken from a letter to Lord Litford, should endear him to every ornithologist: "Anent the dipper, I need not say how I agree with you in loving them. I have three salmon streams in my estates which they haunt. I never allow one to be shot. We have many pairs, but they never seem to increase much. As to their propensities, I have had ocular demonstration that they eat fish, and that greedily. Twice I have seen a dipper with a fish in his bill—one was a trout or salmon fry, the other was a small flounder. This was in the seaport of the river Aray below my house. The flounder was, of course, a small one, but it was as broad as the white waistcoat of its devourer. I had a good glass, and saw the dipper emerge with the little flounder in his bill. He then took it to a large boulder stone near the bank, and began beating it to death against the stone. Twice it slipped off into the stream, and each time it was firmly pursued and brought back to the block! All aquatic piscivorous birds seem to have a way of doubling and folding up the flat fishes they catch so as to get them down, but I did not see the feat performed in the present case."

The following good story is told in another part of the same letter: "I bought two 'civette' (small owls) in Rome, and took them in a cage with me home. We travelled with Gladstone. He was immensely captivated by the brilliant yellow eyes of the birds. They fastened them on Gladstone's brown eyes with a fixed stare, and he took it into his head to try if he could stare them out of countenance. He continued to joke all the way from Rome to near Perugia, and at last the owls gave it up and looked away. He seemed as delighted as if he had won a great Parliamentary triumph." This is dated 1896. His first letter on birds, so far as the biography shows, was written in 1837—and the interest did not flag in the long interval.

SCIENTIFIC ITEMS

WE record with regret the deaths of Professor Alfred Newton, F.R.S., who held the chair of zoology and comparative anatomy at Cambridge; of Dr. Edward John Routh, F.R.S., the mathematician, of the University of Cambridge; of Dr. Maxwell Tylden Masters, F.R.S., the English botanist and horticulturist; of Dr. Alexander Stewart Herschel, F.R.S., honorary professor of physics at the Durham College of Science; of Sir Dietrich Brandis, F.R.S., inspector general of the forests of India; of Professor Kuno Fischer, professor of philosophy at Heidelberg; of Henry G. Hanks, at one time state geologist of California, and of Mrs. Elizabeth Cabot Cary Agassiz, who in 1850 married Louis Agassiz, with whose work she was intimately associated, and whose life she wrote.

THE council of the British Association for the Advancement of Science has nominated Mr. Francis Darwin, F.R.S., foreign secretary to the Royal Society, author of important papers on physiological botany and of the 'Life and Letters of Charles Darwin,' to be president of the meeting next year, when, for the fourth time, the association will assemble in Dublin.—M. de Lapparent, professor of mineralogy and geology at Paris, has been elected permanent secretary of the Paris Academy of Sciences in succession to the late M. Berthelot.—On the occasion of the celebration of the bicentenary of the birth of Linnæus, the Linnean gold medal of the Royal Swedish Academy was awarded to Sir Joseph Hooker.—A portrait of President Eliot by Mr. John P. Sargent has been unveiled in the Harvard Union.

DR. E. H. SELLARDS, for three years geologist and zoologist to the Florida University, has been appointed state geologist of Florida by Governor Brow-

ard.—Dr. E. A. Ruddiman, professor of materia medica and pharmacy at Vanderbilt University, Nashville, has been appointed chief food and drug inspector of the Department of Agriculture.—Dr. Frederick L. Dunlap, instructor in the University of Michigan, has been appointed associate chemist in the Bureau of Chemistry, and will be a member of the board of food and drug inspection.

AN Italian Association for the Advancement of Science, proposed at Milan last year, has now taken form. The first meeting will be held at Parma in September next, when it is hoped that the sister associations of Europe and America will send delegates.

MRS. RUSSELL SAGE has given the sum of $300,000 to found what will be known as the Russell Sage Institute of Pathology as an adjunct to the City Hospital on Blackwell's Island.—Dr. Lawrence F. Flick, director of the Phipps Institute, Philadelphia, and chairman of the committee on the International Congress of Tuberculosis, which is to be held in Washington in the fall of 1908, announces that he has received $35,000 in subscriptions to a fund of $100,000 which he is raising to meet the necessary expenses.